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PALEOBOTANY.—*New occurrences of Pleistocene plants in the District of Columbia.*[1] EDWARD W. BERRY, Johns Hopkins University.

The material which has yielded the organic remains described in the following pages was collected by Mr. Arthur Keith of the United States Geological Survey, whose statement regarding the two outcrops is quoted in subsequent paragraphs. Mr. R. S. Williams of the New York Botanical Garden has identified the mosses for me, and the types of these are in the collection of that institution. Messrs. W. L. McAtee and A. C. Martin of the Bureau of Biological Survey have given valuable help in determining several doubtful specimens and I wish to express my indebtedness to all of these gentlemen for their cooperation.

The two localities are described by Keith[2] as follows:

Government Printing Office: Location on north side of G Street about 200 feet west of North Capitol Street; altitude of curb of G Street 29–30 feet A. T. The excavation went through a heavy fill, then 4 or 5 feet of gravel which may or may not have been in place. Below the gravel the excavation was in dark clay down to 1 foot A. T. Excavations for footings went through about 1 foot down to tide level in dark sandy clay. Fragments of carbonized wood and leaves were found in the upper part of the black clay.

Bellevue Hotel: On north side of E Street and about 200 feet west of North Capitol Street. The excavation was mainly in fill which was 19 feet deep. Beneath this was from 3 to 6 feet of gray clay and gray sandy clay with pockets of vegetable matter, leaves, wood, etc. This clay is the same bed as that cut in the Government Printing Office excavation and seems to correspond to the upper part of the clay

[1] Received July 1, 1932.

[2] Letter of January 26, 1932.

found there. I do not know the precise altitude of the curb in front of the Bellevue Hotel but it is about 8 or 10 feet higher than the curb at the Government Printing Office on G Street.

Altogether the two deposits have yielded the recognizable remains of 41 different kinds of organisms representing 1 fish, 2 insects and 37 kinds of plants. The last comprise 5 mosses, 1 conifer, 2 monocotyledons, and 29 dicotyledons. Four of the plants have not been determined generically, and 11 additional have not been determined specifically. The following 6 types have not before been found fossil in North America and but one of these (*Bidens*) is represented in the European Pleistocene: *Pilea pumila, Cycloloma atriplicifolium, Ilex vomitoria, Helianthemum* sp., *Cornus florida,* and *Bidens* sp.

The bulk of the plant remains represent fruits or seeds, and the leaves of but a single species, *Ilex vomitoria* have been found in the peat, although tiny fragments of leaf lamina, veins, and petioles, are exceedingly common. Leaves of the beech, sycamore, and sweet gum are not uncommon in the silty layer associated with the peat in the excavation for the extension of the Government Printing Office.

There is, in addition, a considerable amount of material from both excavations which I have been obliged to ignore either because of its unsatisfactory nature, or because of lack of skill, or unwillingness to expend the necessary time on account of the law of diminishing returns. For after all, in the few studies which I have had the opportunity to make on Pleistocene plants from the Middle Atlantic and Southern states, the results have disclosed a flora essentially modern and differing in only minor details from that which inhabits the same localities at the present time, and these results are only to be obtained by an inordinate expenditure of time and patience in macerating and sorting the material.

The 5 mosses are all common species and such as might be found in bogs or along streams in the eastern United States. The single conifer, *Taxodium,* is a common Pleistocene type indicative of coastal plain rather than Piedmont environment. Its range has apparently become progressively restricted during the past few thousand years.

Monocotyledons number but 2 species, but of these *Naias* sp. is one of the most abundant plants in the deposits.

The dicotyledons are, for the most part, wide ranging and well known forms, although the 5 following are new to the North American Pleistocene: *Cycloloma atriplicifolium, Ilex vomitoria, Helianthemum* sp., *Cornus florida,* and *Bidens* sp.

While picking over the macerated peaty muck all pebbles en-

countered were preserved and these are of some interest. They are infrequent and mostly small, the largest being a pebble of vein quartz from the Bellevue Hotel site with a maximum diameter of 12 millimeters. Pebbles of vein quartz are the most abundant at both localities and the quartz pebbles are better rounded than those of other materials. From the hotel site pebbles of a chert breccia followed those of vein quartz in frequency and there was a single pebble of red sandstone (apparently Triassic). The pebbles from the muck at the Government Printing Office excavation were rather angular pea-sized gravels or smaller, and the most abundant were of vein quartz. Next in abundance were pebbles of Triassic (?) red sandstone. Very sparingly represented were pebbles of the following: Muscovite, chalcedony, olivine or epidote, fine-grained granite, quartz mica schist, a single one of feldspar, and one or two which were not determined. The assemblage might be called a Piedmont assemblage, having in mind that the Triassic outcrops in the Piedmont province of Maryland. The angularity of the material suggests that it has come only a short distance, unless it be assumed that the small pebbles resulted from the fragmentation of larger and more rounded stream gravel.

The only strictly aquatic plant in the collection is *Naias*, which is very abundant. Conspicuous by their absence are such aquatic genera as *Ceratophyllum*, *Brasenia*, *Nymphaea*, and *Potamogeton*, which might normally be expected to occur and which would scarcely be overlooked if they were represented in the material. On the other hand when one visualizes the plant assemblages characteristic of pond borders or wet stream banks, it is found that the majority of the plants recorded in this paper belong in that category, notably *Carex*, *Alnus*, *Persicaria*, *Polygonum*, *Ranunculus*, *Rubus*, *Vitis*, *Bidens*, etc. Others, like the beech, bald cypress, pig nut hickory, tulip tree, sweet gum, sycamore, elderberry, and *Pilea*, although occurring also in drier situations, are at home and more common in wet situations.

The only strictly dry soil type is the *Helianthemum*, although *Cornus florida* is normally a hillside rather than a stream valley type in this latitude. Moreover, fish scales indicate the presence of sufficient amounts of water to permit this type of life, and the presence of scattered small pebbles at both sites indicates that there was some stream tributary to the immediate area of deposition which was explored.

I conclude then, that these two deposits were laid down in either a pond or in the meanders of a slow-moving stream, the low shores of

which were clothed with thickets of stream-bottom and swamp types of plants.

AGE OF THE DEPOSITS

The altitude and attitude of the present-day surface (30 to 40 feet) beneath which the peaty layers occur at these two sites is that usually referred to the Talbot formation in this region, though the actual elevation of the deposits (less than 20 feet) would suggest a lower terrace, probably the Pamlico terrace. There has been much change of the old natural surface through human agency and the present surface elevation has little physiographic significance. The floras of the various stages of the Pleistocene are so incompletely known and so modern in character that the plants themselves furnish little more than circumstantial evidence.

One naturally compares the flora at these two localities with that described from the Mayflower (Walker) Hotel site on Connecticut Avenue, which is from the somewhat earlier Wicomico formation, and which is the largest flora based upon carpological remains in the eastern United States. Only 7 of the 41 forms from the two localities discussed here were recorded from the Mayflower site and 22 from the latter have not been found at either of the localities under discussion. This seems to me to be an unusually large amount of difference and to be entitled to some weight. How much, cannot be evaluated as the Mayflower site, from the evidence of the large bald cypress stumps and knees in situ, was a cypress pond, whereas these two localities appear not to have been. This undoubtedly means a slightly different ecologic facies and this slight environmental difference might be sufficient to account for the observed differences in the plants found. The most abundant plants at the Mayflower site were the cypress, grape, elderberry, *Rubus*, and sedges—*Carex* and *Dulichium* particularly. None of these are common at the Bellevue Hotel or Government Printing Office sites, in fact only the first three are represented by identical species, and even these are represented sparingly. The commonest fossil at the latter localities is the pericarp of *Naias*. Furthermore, nine of the species in the present paper are commonly found in one or more localities of late Pleistocene age in adjacent regions of the Coastal Plain and three additional are thought to occur elsewhere in the Talbot formation or its equivalent, but are not positively identified.

There is some evidence of a climate more genial than the present in the floral remains from the Mayflower Hotel site. The suggestion

is offered with greater emphasis by the late-Pleistocene marine faunas, and is seen at all localities where plants of Talbot age have been discovered from Virginia northward to New Jersey. It is marked in the assemblage described in this paper, for two species occur that reach their present northern limit in southern Virginia. The evidence for a more genial climate deserves some weight though its exact value is uncertain, particularly for Wicomico deposits, for so few localities with plants of Wicomico age are known that we can neither affirm or deny the point with respect to Wicomico time.

No conclusive correlation has been made between the terrace deposits and those of glacial origin to the northward.

Leverett has identified the terminal moraine of the Illinoian on the north and west branches of the Susquehanna and followed the valley train down the river below Columbia, Pa., where it is said practically to connect with the Wicomico. I am not sure whether Leverett regards these coastal terraces as glacial or interglacial, since he speaks of the degree of weathering of the Pensacola terrace in Florida as indicating an age not older than the Wisconsin drift.[3]

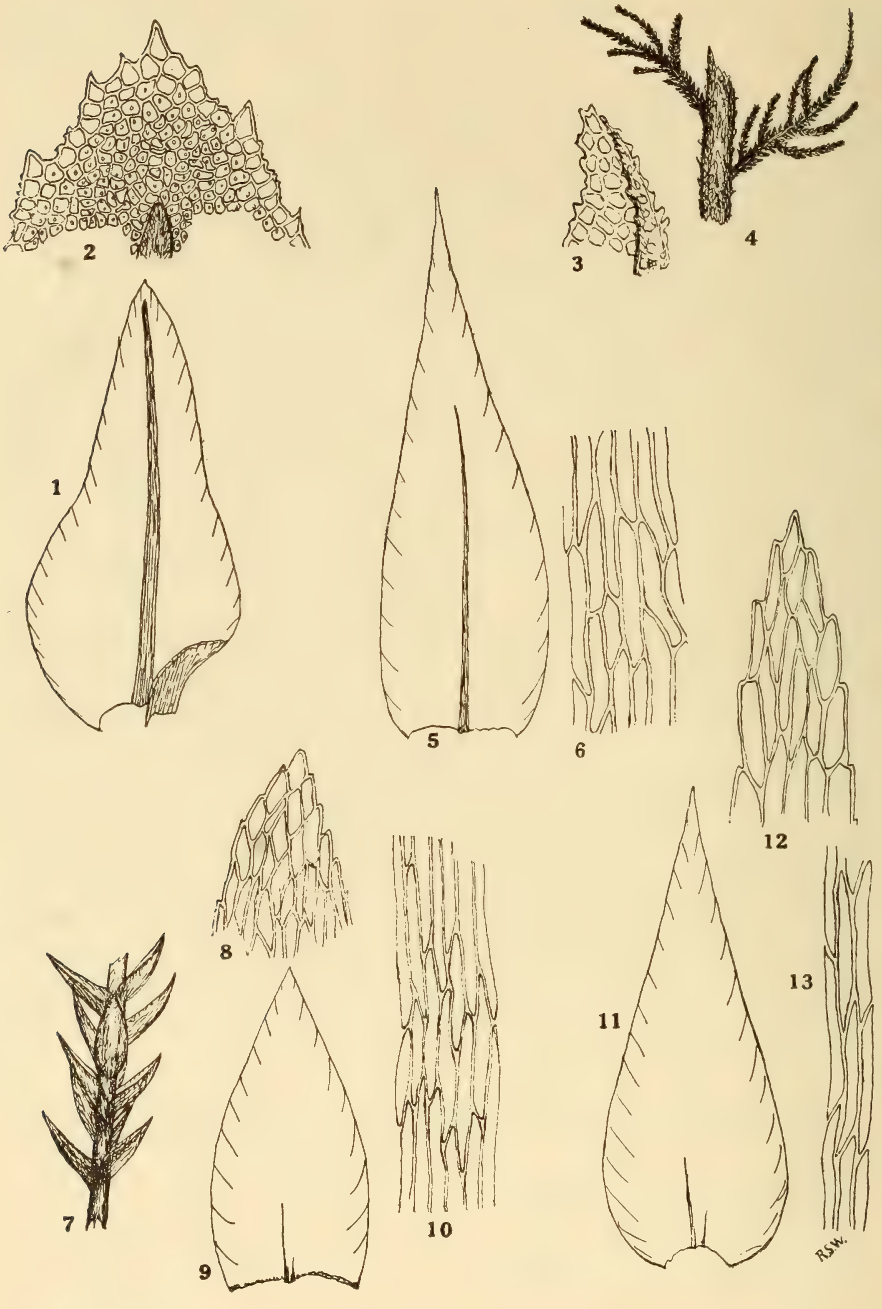
Cooke, who is a strong supporter of the glacial control theory of Pleistocene sea level, considers that the presence of Illinoian drift material in the Wicomico proves the latter to be of Sangamon (interglacial) age.[4] In his latest paper[5] on the subject he advocates restricting the name Talbot to the terrace and formation whose shore line lies about 42 feet above sea level and dropping the term "Chowan," which he suggested as a substitute for Talbot in the previous paper just cited, and using the term Pamlico for the lower terrace whose shore line lies at approximately 25 feet above sea level. If this proposal be adopted, the two fossiliferous sites under discussion would be referred to the Pamlico terrace which probably date, according to Cooke,[6] from the interglacial age between the second and third Wisconsin glaciations.

[3] Leverett, F., Science, vol. 71, p. 544, 1930.

[4] Cooke, C. W., This Journal, vol. 20, p. 394, 1930: Jour. Geol., vol. 38, p. 588 1930.

[5] Idem., vol. 21, pp. 503–513, 1931.

[6] Oral communication.



Figures 1-13. 1-2, *Anomodon attenuatus;* 3-4, *Thuidium delicatulum* or *Th. recognitum;* 5-6, *Brachythecium pulmosum;* 7-10, *Hygrohypnum eugyrium mackayi;* 11-13, *Taxiphyllum geophilum.*

MUSCI[7]

Figs. 1–13.

The interesting fragments of Pleistocene mosses sent to the New York Botanical Garden by Prof. Berry are all blackened and brittle with age. The largest pieces are scarcely more than 1 cm. long, with the main stems or branches often nearly denuded of leaves or with little more than the costa remaining, yet on all the specimens, especially at the tips of the branches, have been found at least a few leaves showing nearly, or quite, perfect outline of margin and cell structure.

As determined, all five species are common and well known mosses of the eastern states and would naturally be found in damp or boggy places. The *Thuidium,* called either *delicatulum* or *recognitum,* can scarcely be more definitely determined without the perichaetial leaves.

The five species are evidently as follows:

Anomodon attenuatus (Schreb.) Hüben.
Thuidium delicatulum (L.) Mitt. or *Thuidium recognitum* (L.) Lindb.
Brachythecium plumosum (Sw.) Bry. Eur.
Hygrohypnum eugyrium mackayi (Schp.) Broth.
Taxiphyllum geophilum (Anst.) Fleisch.

Description of Figures 1-13

Anomodon attenuatus.
Figs. 1. Branch-leaf ×23.
2. Apex of same ×230.

Thuidium delicatulum or *Th. recognitum.*
3. Lateral view of apex of branch-leaf ×200.
4. Part of denuded stem with branches ×6.

Brachythecium plumosum.
5. Branch-leaf ×23.
6. Median leaf-cells ×230.

Hygrohypnum eugyrium mackayi.
7. A section of branch partly denuded of leaves ×6.
8. Apex of branch leaf ×230.
9. Branch leaf ×23.
10. Median cells of same ×230.

Taxiphyllum geophilum.
11. Branch leaf ×23.
12. Apex of same ×230.
13. Median leaf-cells ×230.

[7] Contributed by R. S. Williams of the New York Botanical Garden.

CUPRESSINACEAE

Taxodium distichum (Linné) L. C. Richard

Fig. 14

Taxodium distichum Holmes, Elisha Mitchell Soc. Jour., vol. 2, p. 92, 1885.
Hollick, Maryland Geol. Survey, Pleistocene, pp. 218, 237, pl. 68, 1906.
Berry, Torreya, vol. 6, p. 89, 1906; Jour. Geology, vol. 15, p. 339, 1907; Am. Naturalist, vol. 43, pp. 432–34, figs. 1, 2, 1909; Am. Jour. Sci., 4th ser., vol. 29, p. 391, 1910; Torreya, vol. 10, p. 263, 1910; Plant World, vol. 16, pp. 39–45, figs. 1, 2, 1911; Am. Jour. Sci., 4th ser., vol. 34, p. 219, figs. 1, 2, 1912; Torreya, vol. 14, pp. 160, 162, 1914; U. S. Nat. Mus. Proc., vol. 48, p. 296, 1915; Torreya, vol. 15, p. 206, 1915; U. S. Geol. Survey Prof. Paper 98, p. 195, pl. 45, figs. 1–6, 1916; Jour. Geology, vol. 25, p. 662, 1917; Florida Geol. Survey Ninth Ann. Rept., p. 21, 1917; This Journal, vol. 14, p. 15, pl. 1, figs. 37–42; pl. 3, 1924; U. S. Geol. Survey Prof. Paper 140, p. 105, pl. 45, figs. 1–8, 1926; Torreya, vol. 27, p. 22, 1927.

This species has been found in Pleistocene deposits at numerous localities both within and outside its modern range. The most notable of the latter are Long Branch, N. J., Buena Vista, Va., and Marietta, Ga. All of the Maryland—District of Columbia Pleistocene occurrences are outside the Recent range but at no very great distance, although those near the head of Chesapeake Bay are about 60 miles outside the present range. The localities previously mentioned are three times this distance and the Virginia and Georgia localities are situated in the Appalachian Province.

Within the District of Columbia huge stumps, accompanied by a profusion of seeds and somewhat fewer cone scales, were found at the Mayflower (Walker) Hotel site on Connecticut Avenue, and the wood was also found in an excavation at the southeast corner of North Capitol and Pierce Streets, N. E. The species was found at both the Bellevue Hotel excavation and that for the Government Printing Office extension. At the former there were only a few seeds but at the latter place, detached leaves, a few broken twigs, a small cone-scale, and a few abortive seeds were found. Obviously the peat at these two localities does not represent a cypress pond or bay like that at the Mayflower (Walker) Hotel site, but a sparse drift element derived from a source some little distance away.

The bald cypress has a most interesting geologic history, and its immediate and scarcely distinguishable Tertiary ancestor attained a holarctic distribution in the later Tertiary.

The oldest beds in which the existing species has been definitely recognized are the Pliocene deposits along the Gulf coast of Alabama (Citronelle formation). It was exceedingly common at numerous widespread localities in southeastern North America during the Pleistocene epoch in the latest terrace deposits (Talbot, Pamlico, and Princess Anne) and in several sub-Recent deposits. Unfortunately it does not seem possible now to correlate the outcrops at these localities with the chronology of the glaciated region to the north.

The Flora of the District of Columbia[8] records the bald cypress from near Marshall Hall, about 20 miles down the Potomac Valley, and also from localities south of Bowie, Prince George's County, Maryland about an equal distance east of the District, but I have never observed it under unquestionable natural conditions nearer than southern Charles County, Maryland.

NAIADACEAE

Naias sp. Berry

Figs. 15–20.

Naias sp. Berry, This Journal, vol. 14: p. 17, pl. 1, figs. 1–3, 1924.

Very many pericarps of a species of Naias similar to those encountered at the Mayflower (Walker) Hotel site are contained in the material from the excavation for the extension of the Government Printing Office and more sparingly at the Bellevue Hotel site. Some of these are in an excellent state of preservation and show a fine longitudinal ornamentation of punctate riblets. The photographs from which the accompanying illustrations were made are particularly poor and do not bring out these features.

POACEAE

Carex sp.

Fig. 21

In addition to immature and undeterminable specimens, the achenes of two species of Carex were found to be exceedingly common in the buried swamp deposit encountered in the excavation at the site of the Mayflower (Walker) Hotel. These were compared with *Carex collinsii* Nuttall[9] and *Carex intumescens* Rudge.[10] In the excavation for the extension of the Government Printing Office a single achene of a *Carex* was discovered. This appears to me to be distinct from the two species cited above, but the species in this genus are so numerous and there is so much convergence in the fruiting characters of many of them, that the specific identity of the most similar of existing forms can not be determined from the fruits alone.

JUGLANDACEAE

Hicoria glabra (Mill.) Britton

Figs. 22, 23

Juglans glabra Mill. Berry, Torreya, vol. 6, p. 89, 1906; Jour. Geol., vol. 15, p. 340, 1907; Torreya, vol. 9, p. 97, figs. 1–5, 1909; Idem., vol. 10, p. 264, fig. 1, 1910; U. S. Geol. Survey Prof. Paper 140, p. 106, pl. 46, figs. 1–4, 1926.

[8] Cont. U. S. Natl. Herbarium, Washington, 1919.

[9] Berry, E. W., This Journal, vol. 14, p. 17, pl. 1, figs. 4–8, 1924.

[10] Idem, figs. 9–11.

Hicoria pseudo-glabra Hollick, Md. Geol. Survey Pliocene & Pleistocene, p. 221, pl. 72, figs. 1, 16, 17, 1906.

Carya porcina Nuttall. Mercer, Acad. Nat. Sci. Phila. Jour., (II), vol. 11, p. 277, 281, figs. 4, 5, 12, 16, 1899.

Half of a nut and husk fragments of this species were found in the Government Printing Office excavation. It has been recorded from a considerable number of Pleistocene deposits ranging in age from the Sunderland terrace to the "Chowan" (Talbot) terrace. It has been found in the Port Kennedy, Penna., cave deposit, and in New Jersey, Maryland, Virginia, and North Carolina. In the existing flora it is found in both dry and wet situations from Maine to Florida and Texas.

BETULACEAE

Alnus rugosa (Du Roi) K. Koch

Figs. 24–27

(?) *Alnus serrulata* Willdenow. Schmalhausen, Palaeont., Bd. 33, p. 200, pl. 19, figs. 5–9, 1887.

Alnus rugosa Hollick, Md. Geol. Survey Pliocene and Pleistocene, p. 225, pl. 69, figs. 1–3, 1906.

The cone scales of this species are rather common at both the Bellevue Hotel excavation and that for the Government Printing Office extension. One or two shrivelled and doubtfully determined seeds were also found. The latter are slender but show the two persistent styles and are probably abortive seeds of this species, since they are not filled out.

Leaves of this species are exceedingly common in the Talbot clays at Drum Point, Calvert County, Md. This is the only previously recorded fossil occurrence except for the forms from the supposed Pliocene of the Altai region in Asia which Schmalhausen identified as *Alnus serrulata* Willdenow. The latter is a synonym of *Alnus rugosa* and it is highly improbable that the Altai occurrence represents this, rather than one of the numerous existing Asiatic species of the genus.

Alnus is an old genus recorded somewhat doubtfully from the Upper Cretaceous and attaining a Holarctic range during the Tertiary, and penetrating South America as far as Bolivia in the Pliocene. The existing species are clearly foreshadowed in the Pliocene, Schmalhausen having referred several from the Altai region in Asia to modern forms, and Saporta and Laurent describing French species as varieties of existing ones.

In addition to the present species *Alnus rubra, incana, viridis, glutinosa,* and *cordifolia* have been recorded from the Pleistocene.

Alnus rugosa is common in swamps and on low moist ground in the present flora of the District of Columbia and ranges from Maine and Minnesota to Florida and Texas.

FAGACEAE

Fagus grandifolia Ehrhart

Fagus ferruginea Lesquereux, Am. Jour. Sci., vol. 27, p. 363, 1859; Geol. Tenn., p. 427, pl. K, fig. 11, 1869 (?).
Knowlton, Am. Geol., vol. 18, p. 371, 1896.
Mercer, Acad. Nat. Sci. Phila. Journ., (II), vol. 11, pp. 277, 281, fig. 815, 1899.
Fagus americana Hollick, Md. Geol. Survey Pliocene & Pleistocene, p. 226, 1906.
Berry, Torreya, vol. 6, p. 88, 1906; Jour. Geol., vol. 15, p. 341, 1907; Am. Nat., vol. 41, p. 692, pl. 2, fig. 7, 1907; Idem., vol. 43, p. 435, 1909; Am. Jour. Sci., vol. 29, p. 393, 1910; Torreya, vol. 14, p. 162, 1914; Idem., vol. 15, p. 206, 1915; U. S. Geol. Survey Prof. Paper 140, p. 108, pl. 48, figs. 3–13, 1926; Torreya, vol. 27, p. 25, 1927.

In the drab clay layer in the excavation for the Government Printing Office impressions of beech leaves are exceedingly common, although no traces of the nuts or husks have been found in the associated peaty layers.

Leaves, nuts or seeds of this species have been recorded from a variety of horizons in the Pleistocene, and from Massachusetts to Texas. With the exception of the Massachusetts locality and those in the Port Kennedy, Penna., cave, and in the glacial terrace at Morgantown, West Virginia, the records are confined to the Atlantic Coastal Plain and include the states of Maryland, Virginia, North Carolina, Alabama, Mississippi, and Texas. The modern range is on rich soil from Nova Scotia, Ontario, and Wisconsin to Florida and Texas.

PLATANACEAE

Platanus occidentalis Linné

Platanus aceroides Hollick (not Goeppert), Md. Geol. Survey Pliocene and Pleistocene, p. 231, pls. 73 and 74, 1906.
Platanus sp., Hollick, Idem., p. 232, pl. 75, 1906.
Platanus, leaf fragments. Mercer, Acad. Natl. Sci. Phila. Jour., (II), vol. 11, p. 277, 1899.
Platanus occidentalis Knowlton, Am. Geol. vol. 18, p. 371, 1896.
Penhallow, Roy. Soc. Canada Trans., (II), vol. 2, sec. 4, pp. 68, 72, 1896; Am. Nat., vol. 41, p. 448, 1907.
Berry, Jour. Geol., vol. 15, p. 344, 1907; Am. Nat., vol. 41, p. 695, pl. 2, fig. 5, 1907; Am. Jour. Sci., vol. 29, p. 397, 1910; Torreya, vol. 14, p. 161, 1914; Idem., vol. 15, p. 207, 1915; U. S. Geol. Survey Prof. Paper 140, p. 112, pl. 55, figs. 1–9, 1926.
Emerson, U. S. Geol. Survey Bull. 597, p. 148, 1917.

This species occurs as leaf impressions associated with the peat at the excavation for the Government Printing Office extension. In the associated peat there are pieces of bark and fragments of leaves, usually a small part at the base with more or less of the petiole. The bark is also present in the Bellevue Hotel excavation.

This species has been found fossil in the Don Valley near Toronto, near Hadley, Mass., at Morgantown, W. Va., in both the Sunderland and Talbot

formations of Maryland, in the Port Kennedy cave, Penna., in the "Chowan" (Talbot) formation of North Carolina, and in the lowest terraces of the Chattahoochee, Alabama, and Warrior rivers in Alabama.

The existing tree is essentially a stream bank and wet woods form and is found from Maine and Ontario to Florida and Texas.

URTICACEAE

Pilea pumila (Linné) A. Gray

Fig. 33

A single specimen from the excavation for the Government Printing Office extension appears to be closest to the seeds of this species although somewhat above the average size. The genus is large and mostly tropical with two temperate North American herbaceous species of shaded swampy situations. In the existing flora this species ranges from New Brunswick to western Ontario and Minnesota and southward to Kansas, Florida, and Louisiana. It is common on moist, generally alluvial soil in the present flora of the District of Columbia.

The fruit is a much compressed, ovate, acute achene with a flat seed. It has not heretofore been found fossil.

ULMACEAE

Ulmus alata Michaux

Fig. 34

This species was recorded by Lesquereux[11] from the Pleistocene on the banks of the Mississippi near Columbus, Kentucky. This record may be correct but I am inclined to doubt it as I revisited Lesquereux's locality and made collections which I, at first, mistook for Pleistocene, but which turned out to be Jackson Eocene. I found no trace of *Ulmus,* and this species does not, of course, occur in the Eocene.

I have recorded this species from the Pleistocene of North Carolina ("Chowan" formation)[12] and Alabama.[13] These occurrences were based on the leaves and this is the first fossil record of the fruit. These fruits are not uncommon at the excavations for the Bellevue Hotel and the extension of the Government Printing Office. I refer them to *Ulmus alata* rather than to *Ulmus americana* Linné, because of their smaller size, extended slender stalk, shorter notch, more pointed tip, and more slender and extended styles.

[11] Lesquereux, Leo, Am. Jour. Sci., vol. 26, p. 365, 1859.

[12] Berry, E. W., Jour. Geol., vol. 15, p. 343, 1907; U. S. Geol. Survey Prof. Paper 140, p. 111, pl. 54, figs. 1, 2, 1926.

[13] Berry, E. W. Am. Nat., vol. 41, p. 694, pl. 1, figs. 6, 7, 1907; Am. Jour. Sci., vol. 29, p. 396, 1910.

At the present time this species occurs both on dry uplands and deep soil of swamp borders and stream banks. It reaches its northern limit in southern Virginia, ranging southward to western Florida, and from southern Indiana and Illinois to Trinity River, Texas.

POLYGONACEAE

Persicaria pennsylvanicum (Linné) Small

Figs. 37, 38

Achenes suborbicular, lenticular or flat, short-pointed, smooth, 2 to 2.5 millimeters high and approximately the same width.

This species occurs in the excavation for the Government Printing Office extension. Several specimens were collected. In the present flora of the District of Columbia it is common in wet situations. Outside the District its range is extensive, reaching northward to Nova Scotia and Ontario and southward to Florida and Texas.

Persicaria sp. cf. P. hydropiperoides (Michx.) Small

Figs. 35, 36

A few small triangular achenes, similar to those of *Persicaria hydropiperoides* but somewhat smaller, were present in the excavation for the Government Printing Office extension. This species was common in the Wicomico at the Mayflower (Walker) Hotel site[14] and in the existing flora it ranges from southern Canada to Florida and Mexico in wet situation. It is not common in the existing flora of the District of Columbia, although recorded from several stations along the Potomac.

The genus makes its appearance in the late Miocene in Japan, Central Europe, and at Florissant, Colorado. Several existing species are recorded from the Pleistocene in Europe and North America and specifically undetermined specimens are recorded from the following localities and horizons in our eastern American Pleistocene: Loess of western Tennessee,[15] at Scarboro, Ontario,[16] Talbot formation of Maryland,[17] Wicomico formation of District of Columbia,[18] Talbot ("Chowan") formation of North Carolina,[19] and the plant-bearing deposits at Vero, Florida.[20] These are usually referred to the Linnean genus *Polygonum*.

[14] Berry, E. W., This Journal, vol. 14, p. 19, pl. 1, figs. 19–22, 1924.
[15] Berry, E. W., Torreya, vol. 22, p. 11, 1922.
[16] Coleman, A. P., Geol. Soc. Am. Bull., vol. 26, p. 247, 1915.
[17] Hollick, Arthur, Md. Geol. Survey Plio-Pleistocene, p. 231, 1906.
[18] Berry, E. W., This Journal, vol. 14, p. 19, pl. 11, fig. 23, 1924.
[19] Berry, E. W., U. S. Geol. Survey Prof. Paper 140, p. 112, 1926.
[20] Berry, E. W., Jour. Geol., vol. 25, p. 662, 1917.

Polygonum sp.

Figs. 39, 40

Two specimens of immature fruits of some species of *Polygonum* are figured from the excavation for the Bellevue Hotel. They are possibly of the same species differing merely in size, and are of the compressed lenticular type.

Polygonum is widely distributed with many species in the existing flora. It is not known in the geological record earlier than the middle Miocene. Several recent species are recorded from the Pleistocene in both Europe and North America. The latter, specifically unnamed include the Wicomico formation at the Mayflower (Walker) Hotel site, the Talbot formation of Maryland, the Talbot ("Chowan") formation of North Carolina, and from Scarboro, Ontario, and Vero, Florida.

Polygonum sp.

Fig. 41

An achene, probably immature, lenticular in section, surmounted by two persistent pistils. Seems clearly referable to *Polygonum* but cannot be satisfactorily identified as to species.

Excavation for extension of the Government Printing Office.

PHYTOLACCACEAE

Phytolacca decandra Linné

Berry, Torreya, vol. 14, p. 121, 1914; This Journal, vol. 14, p. 19, pl. 1, figs. 26–28, 1924.

A seed of this species is contained in the material from the Government Printing Office extension. It has previously been recorded from the Mayflower (Walker) Hotel site on Connecticut Avenue and from the lowest terrace of the Chattahoochee River in Alabama.

In the Recent flora it ranges from Maine, Ontario, and Minnesota to Florida and Texas. It is common in the District of Columbia, and here, as elsewhere within its range, occurs in rich moist soil or on waste ground. According to the Botanical Code its proper name is *Phytolacca americana* Linné.

CHENOPODIACEAE

Cycloloma atriplicifolium (Sprengel) Coulter

Fig. 42

A single specimen of a marginally winged circular fruit is contained in the collection from the excavation for the extension of the Government Printing Office. The central part is circular, about 1.6 millimeters in diameter and

depressed. It is surrounded by a marginal wing most of which was abraded before fossilization so that only a narrow basal part is preserved all round, and this contains radiating vascular strands.

I have compared this specimen with all the winged fruits or seeds that I could think of as likely to occur in this region without success and at the suggestion of W. L. McAtee compared it with the fruits of this species, with which there is substantial and convincing agreement except that the modern fruits are slightly larger. This difference in size amounts to possibly 25 per cent without making any allowance for variation or for degree of maturity of the fossil and is not sufficient to warrant considering the difference as specific.

The modern species is a herbaceous form of stream banks, and ranges from Manitoba to Indiana and westward to Nebraska and Arizona. It is unknown east of the Alleghanies.

The fruit is a depressed utricle with a persistent calyx which forms the horizontal winged margin. *Cycloloma* is a monotypic genus previously unknown as a fossil and there is a possibility that the present occurrence may represent an extinct species, but I would not be inclined to consider this until more than this single specimen has been discovered.

RANUNCULACEAE

Ranunculus sp.

Fig. 43

Achenes flat, squarish in outline, mucronately tipped, relatively large.

Sparingly represented in the excavation for the Government Printing Office extension. There is some resemblance to *Ranunculus abortivus* Linné although the fossil is larger. It differs from any of the *Ranunculus* fruits collected from the Wicomico at the Mayflower (Walker) Hotel site.[21] There are 12 species of *Ranunculus* in the present flora of the District of Columbia. The genus is well represented in the Pleistocene of Europe and will doubtless be found to be equally common in the North American Pleistocene when the latter is studied as intensively as the former. *Ranunculus* contains over 200 species of herbs, is almost cosmopolitan in its distribution, and occurs in the geological record from the Oligocene onward.

Ranunculus sp.

Fig. 44

The specimen figured appears to represent an achene of a large fruited species of *Ranunculus*, and its flattened condition suggests immaturity. With its beak it is slightly over 2.5 millimeters in length and about 1.5 millimeters in breadth.

[21] Berry, E. W., This Journal, vol. 14, p. 20, pl. 1, figs. 29–31, 1924.

Figures 14–77

It differs decidedly from the preceding as well as from the several *Ranunculus* achenes figured from the Mayflower (Walker) Hotel site[22] but is most like that shown in Fig. 41, although it apparently represents a distinct species.

Excavation for extension of the Government Printing Office.

Figures 14–77

All the figures except 9 and 10 are enlarged about 3 times.

B. H. indicates that the specimens came from the Bellevue Hotel site, and G. P. O. that they came from the excavation for the extension of the Government Printing Office.

Figures 14. Terminal twig of *Taxodium distichum* (Linné) L. C. Rich. G. P. O.
15–20. Pericarps of *Naias* sp. G. P. O.
21. *Carex* sp. G. P. O.
22. Half of a nut of *Hicoria glabra* (Mill.) Britton, nat. size. G. P. O.
23. Part of husk of same, nat. size. G. P. O.
24–27. Cone-scales of *Alnus rugosa* (DuRoi) K. Koch.
28–32. Partially decorticated seeds of *Liriodendron tulipifera* Linné. B. H., 19. G. P. O.
33. *Pilea pumila* (Linné) A. Gray. G. P. O.
34. Winged fruit of *Ulmus alata* Michaux. G. P. O.
35–36. *Persicaria* sp. cf. *P. hydropiperoides* (Michaux) Small. G. P. O.
37–38. *Persicaria pennsylvanica* (Linné) Small. G. P. O.
39–40. *Polygonum* sp. B. H.
41. *Polygonum* sp. G. P. O.
42. *Cycloloma atriplicifolium* (Sprengel) Coulter. G. P. O.
43. *Ranunculus* sp. G. P. O.
44. Achene of a second species of *Ranunculus*. G. P. O.
45–47. Broken samaras of *Liriodendron tulipifera* Linné. B. H.
38, 39. Immature stones of *Rubus* sp. G. P. O.
50. Prickle. *Rubus* (?). G. P. O.
51, 52. Seeds of *Vitis cordifolia* Michaux. G.P.O.
53, 54. Tendrils. *Vitis* (?). G. P. O.
55, 56. Leaves of *Ilex vomitoria* Ait. G. P. O.
57–59. *Helianthemum* sp. G. P. O.
60. *Sambucus canadensis* Linné. G. P. O.
61, 62. Transverse profile and side view of stone of *Cornus florida* Linné. B.H.
63. Part of a stone of *Nyssa sylvatica* Marsh. B. H.
64, 65. *Bidens* sp. B. H.
66. *Xanthium* sp. G. P. O.
67. Undeterminable capsular valve. G. P. O.
68–70. Undeterminable fruit peduncles. G. P. O.
71. Cyprinodont fish scale. B. H.
72–77. Gall scales.

[22] Berry, E. W., This Journal, vol. 14, p. 24, pl. 1, figs. 29–32; pl. 2, fig. 28, 1924.

MAGNOLIACEAE

Liriodendron tulipifera Linné

Figs. 28–32 and 45–47

Liriodendron tulipifera Berry, Amer. Nat., vol. 41, p. 695, 1907; Torreya, vol. 9, p. 71, fig. 1, 1909; Am. Jour. Sci., vol. 29, p. 396, 1910; Torreya, vol. 15, p. 208, fig. 1, 1915; U. S. Geological Survey Prof. Paper 140, p. 112, pl. 54, figs. 6–8, 1926.
Schmalhausen, Palaeontographica, Bd. 33, p. 211, pl. 21, figs. 20, 21, 1887.
Reid, C. & E. M., Pliocene Flora Dutch Prussian border, p. 93, pl. 8, figs. 1–5, 1915.

This species has been recorded from the supposed Pliocene of the Altai region of Asia; the Pliocene of Holland, and the Pleistocene of Maryland, North Carolina, and Alabama. Schmalhausen's Altai material was of leaf fragments which undoubtedly belong to *Liriodendron* but whether to this species or to the existing *Liriodendron chinensis* of China it is impossible to determine, as the two were thought to represent the same species until the flowers and fruit of the Chinese form became known. The Pliocene material from Holland, represented by both fruits and seeds, is considered by the Reids to be the modern American form and to differ characteristically from the Chinese form.

In the Atlantic Coastal Plain leaves have been found in the Talbot of Maryland, southeast of Washington, in the Wicomico of North Carolina, and in the lowest terrace of the Warrior River in Alabama. Fruits have been found in the lowest terrace of both the Warrior and Chattahoochee rivers in Alabama.

In the present collection the somewhat broken samaras and their wing fragments as well as partly decorticated seeds are not uncommon in both the excavation for the Government Printing Office extension and at the Bellevue Hotel, being especially abundant at the latter locality. They are indistinguishable from the corresponding parts of Recent specimens.

The living species is a tree of woodlands with deep, rich soil. It reaches its northeastern limits in Rhode Island and southern Vermont.

HAMAMELIDACEAE

Liquidambar styraciflua Linné

Hollick, Torrey Bot. Club Bull., vol. 19, p. 331, 1892.
Knowlton, Am. Geol., vol. 18, p. 371, 1896.
Berry, Jour. Geol., vol. 15, p. 343, 1907; Am. Jour. Sci., vol. 29, p. 397, 1910; U. S. Geol. Survey Prof. Paper 140, p. 113, pl. 56, figs. 9, 10, 1926.

Leaves or fruit of this species have been recorded from the supposed Pliocene at Bridgeton, N. J.; from the glacial terrace at Morgantown, West Virginia; from the Talbot ("Chowan") formation of North Carolina; and from the lowest terrace of Warrior River in Alabama. A small but perfect leaf is present in the drab clay associated with the peat at the excavation for the Government Printing Office extension.

The modern tree is a form inhabiting low moist woodland and ranges from southern New England to Florida.

ROSACEAE

Rubus sp.

Figs. 48, 49

A very few stones of a *Rubus* were found in the deposit at the Government Printing Office extension. These are specifically distinct from the *Rubus* which was so common in the Wicomico deposits at the site of the Mayflower (Walker) Hotel on Connecticut Avenue,[23] which was compared with *Rubus hispidus* Linné, one of the six species present in the existing flora of the District of Columbia. The present stones are smaller and more rounded with a much finer pitting. The photograph is poor in that it does not bring out well the characteristic ornamentation and the somewhat shrunken, or not well filled out condition of the specimen, causes a circular central shadow in what was originally a convex surface. Some of the specimens are obviously immature. A considerable number of Pleistocene species of *Rubus* have been recorded from European deposits but in this country where the study of Pleistocene floras is still in its infancy *Rubus* fruits have not been recorded outside the District of Columbia except for a single record from Alabama.[24]

The genus *Rubus* is a large one with upwards of 300 existing species of perennial herbs, shrubs or vines, and is widely distributed throughout the world, being found on all of the continents, most abundant, perhaps, in the North Temperate Zone.

Prickle of Rubus (?)

Fig. 50

A prickle such as occurs in a variety of plants, particularly in the Rosaceae, was found in the excavation for the extension of the Government Printing Office. It is smaller, relatively more slender, and decidedly more falcate than the one figured from the Mayflower (Walker) Hotel site[25] and is a different species. Of course, such remains can not be positively identified generically. The specimen from the Mayflower Hotel site was identified as a prickle of *Rosa* or *Rubus*. The present specimen is considered as more likely to represent the latter genus.

[23] Berry, E. W., This Journal, vol. 14, p. 20, pl. 2, fig. 1, 1924.
[24] Berry, E. W., Torreya, vol. 14, p. 161, 1914.
[25] Berry, E. W., This Journal, vol. 14, p. 24, pl. 2, fig. 27, 1924.

ILICACEAE

Ilex vomitoria Ait.

Figs. 55, 56

Two leaves of this species are present in the peat from the excavation for the extension of the Government Printing Office. The species has not previously been found fossil.

In the existing flora this species is a shrub, or small, much branched tree confined to the Coastal Plain in low woods, and ranging from southern Virginia to Florida and westward to Arkansas and Texas. The coriaceous evergreen leaves show considerable variation in form but have a characteristic margin. This is often described as crenate (as in Britton & Brown's Illustrated Flora) but it is not. The low, broad crenations at their distal extremity, end in serrate points for which the proper term would seem to be crenate-serrate. The fossil leaves are thick in substance and show the typical marginal features just mentioned, so that there can be no doubt of the correctness of the identification.

VITACEAE

Vitis cordifolia Michaux

Figs. 51, 52

Berry, This Journal, vol. 14, p. 21, pl. 2, figs. 6–9, 1924.

About a dozen specimens of the seeds of this species, mostly broken, have been found in the excavation for the Government Printing Office extension. They are identical with the smaller specimens from the Mayflower (Walker) Hotel site, where this species was exceedingly abundant.

The species is one inhabiting moist thickets and stream banks and it ranges in the Recent flora from New England to Florida and Texas. Pleistocene grape seeds have been recorded in the Atlantic Coastal Plain in New Jersey, Maryland, and Virginia. Although not named specifically it seems probable that those from the Talbot formation of Maryland and Virginia represent this species.

Tendrils which may be those of *Vitis* occur at the Government Printing Office excavation and similar remains have been referred to *Vitis* from the Talbot ("Chowan") formation of North Carolina.[26]

Tendrils, cf. Vitis

Figs. 53, 54

Two incomplete tendrils were found in the peaty stratum in the excavation for the Government Printing Office extension. Although they can not be

[26] Berry, E. W., U. S. Geol. Survey Prof. Paper 140, p. 115, pl. 57, fig. 6, 1926.

referred to *Vitis* with certainty their association with grape seeds renders this assignment probable. They are exactly like the remains from the Talbot ("Chowan") formation of North Carolina which I ventured to identify as those of *Vitis*.

CISTACEAE

Helianthemum sp.

Figs. 57–59

Three specimens from the excavation for the extension of the Government Printing Office seem clearly to represent valves of capsules of the genus *Helianthemum*. One of these appears to be mature and the other two immature or depauperate, although it is impossible to be sure, because the flowers in this genus are dimorphic and the apetalous ones appear later than the petaliferous ones and develop into smaller capsules.

The valves are nearly circular, slightly ovate or slightly obovate, with central placenta, about 2.5 millimeters in diameter, of considerable consistency, and in the larger specimen containing a large seed.

The surface marking of the latter is indistinct but it appears along the margins to have been papillose rather than reticulate, although there is some uncertainty regarding the correctness of my observation.

The genus is large, herbaceous or shrubby, and found on all of the continents except Australia, and hence must be of some antiquity, although, so far as I know, it has not hitherto been found fossil. About a dozen existing species occur within the limits of the United States, 3 of these along the Atlantic seaboard. The only one of these in the present flora of the District of Columbia is *Helianthemum canadense* (Linné) Michaux, a dry soil species ranging from Maine to North Carolina. The fossil may represent this species, but absolute certainty is not possible.

CORNACEAE

Cornus florida Linné

Figs. 61, 62

A single stone of this species is contained in the material from the Bellevue Hotel site. It is not quite 6 millimeters long and is therefore near the minimum size for modern stones of this species. The proportions are the same and the fossil is slightly asymmetric and slightly wider than it is thick. There are 8 or 10 shallow longitudinal sulcae slightly more prominent than in any modern stones that I have seen, although no extended search has been made. I have slight doubt but that the fossil represents this species as the differences enumerated are too trifling to be considered of specific or varietal value and no other existing American species approaches *Cornus florida* in the form or other features of its stones.

So far as I know this is the first record of our flowering dogwood as a fossil. It is a large shrub or small tree of eastern North America ranging from Maine and Ontario to Texas. It is essentially a woodland and hillside species rather than a valley or bottom type and is abundant in the present flora of the District of Columbia.

The genus goes back to the Upper Cretaceous and has about 25 existing species for the most part confined to the North Temperate zone although reaching South America in the northern Andes. Several other existing species have been found in the Pleistocene. These include *Cornus mas* Linné and *Cornus sanguinea* Linné in the European region, an undetermined species in New Jersey,[27] *Cornus californica* C. A. Meyer in California,[28] and *Cornus amomum* Mill[29] which is fairly common in the Wicomico formation at the Mayflower (Walker) Hotel site on Connecticut Avenue.

The accompanying photograph is a somewhat misleading portrayal since there is an irregular film of carbonized flesh over most of the surface of the stone.

NYSSA SYLVATICA Marsh

Fig. 63

This species has not heretofore been positively recorded as a fossil, although in all probability it is included among the numerous Pleistocene records of *Nyssa biflora* Walt., the latter having been recorded from New Jersey, Maryland, Virginia, North Carolina, and Alabama. There also seems to be some confusion among botanists in regard to the specific limits among the existing forms, the second being thought to range less farther northward.

The present occurrence is based upon an incomplete stone from the Bellevue Hotel site. The modern tree is present in the flora of the District and has a recorded range from Maine and Ontario to Florida and Texas. It is a rich soil form, most abundant in swampy situations.

CAPRIFOLIACEAE

SAMBUCUS CANADENSIS Linné

Fig. 60

Berry, This JOURNAL, vol. 14, p. 23, pl. 2, figs. 21–24, 1924.

The characteristic seeds of the elder-berry were present in considerable profusion at the Mayflower (Walker) Hotel site on Connecticut Avenue, which is the only previous Pleistocene record of this species. A few of these seeds are present in the excavation for the Government Printing Office extension.

[27] Penhallow, D. P., Roy. Soc. Canada Trans. 2nd ser., vol. 2, sec. 4, p. 70, 1896.
[28] Chaney and Mason, Carnegie Institution Publ. 415, p. 14, pl. 7, figs. 19, 20, 1930.
[29] Berry, E. W., This JOURNAL, vol. 14, p. 22, pl. 2, figs. 15–18, 1924.

The species is still abundant in the District of Columbia, and is found in wet situations from Nova Scotia to Florida and Texas.

AMBROSIACEAE

Xanthium sp.

Fig. 66

Authors are not agreed on the specific limits in this genus. According to Britton and Brown there is but a single native species in the eastern United States, *Xanthium canadense* Mill, and the present single fossil specimen may represent that species, although it is below the average in size and stoutness. The tips of the beaks are broken so that their length can not be determined. It comes from the excavation for the extension of the Government Printing Office.

A fruit of *Xanthium*, probably *X. glabratum* (D.C.) Britton has been recorded[30] from Vero, Florida, and two others were collected by me from the lowest terrace of the Chattahoochee River in Alabama, which latter were never described because I could not be sure that they were not Recent and had not gotten among the fossils by accident, although they had the appearance of being fossil.

Both of the supposed native species are recorded in the Flora of the District of Columbia from the Potomac flats, and both are found along rivers and sea beaches as well as in what are euphemistically spoken of as "waste places."

COMPOSITAE

Bidens sp.

Figs. 64, 65

There are 10 of the 13 species of *Bidens* of the eastern United States recorded in the Flora of the District of Columbia. The two fossil achenes found in the Bellevue Hotel excavation are unmistakable, but it is easier to decide which of the modern species the fossils do not belong to than it is to tell which they do represent. They are flat; with 2 rigid downwardly barbed awns and are about 7 mm. long and 2–2.5 mm. wide. In my opinion they could represent *B. laevis*, *connata*, *comosa*, or *frondosa*.

In so far as I know, the genus has not heretofore been recorded from American Pleistocene deposits, although two species have been recorded from the Pleistocene of Europe.

[30] Berry, E. W., Jour. Geol., vol. 25, p. 662, 1917.

Capsular valve

Fig. 67

A rather crustaceous valve of a capsule of some undeterminable plant. Excavation for extension of the Government Printing Office.

Fruit peduncle

Figs. 68–70

Several specimens of the peduncle of some small fruit occur in the excavation for the Government Printing Office extension. They are small, about 3 millimeters long, slender, and enlarged distad to a receptacle about twice the diameter of the stalk.

There are so many genera that have similar fruit peduncles that their botanical affinity must remain conjectural, although *Celastrus, Ilex, Ampelopsis, Rhamnus,* and related genera in the families to which they belong seem to me to be the most likely comparisons.

DIPTERA: ITONIDIDAE

Retinodiplosis taxodii Felt

Retinodiplosis sp., Berry, This Journal, vol. 14, p. 24, pl. 2, figs. 32–34, 1924.

These galls, which were exceedingly abundant at the Mayflower (Walker) Hotel site are represented by a broken specimen from the excavation for the Government Printing Office extension. They are caused in bald cypress cones by gall midges. The fossils are believed to represent this Recent species. That these galls should be scarce is, I believe, a reflection of the absence of bald cypress trees in the immediate vicinity of the pond or stream where the deposits accumulated since remains of the bald cypress are also infrequent, whereas at the Mayflower Hotel site the stems of cypress trees representing several generations were buried in the peat, and seeds, cone scales, twigs, detached leaves, and galls were exceedingly abundant.

Fish scale

Fig. 71

That permanent standing or running water had access to the site of the carbonaceous deposit encountered in the excavation for the Bellevue Hotel is indicated by occasional fish scales of some small cyprinodont fish. One of these is shown in the accompanying illustration.

Gall scales

Figs. 72–77

Both the Bellevue Hotel excavation and that for the extension of the

Government Printing office abound with gall scales. I do not recall encountering anything of the sort in the large amount of material from the Mayflower (Walker) Hotel site which I examined.

I have not attempted to identify them, nor do I recall any records of such objects as fossils except in the recently published account of the Pleistocene flora from Santa Cruz Island, California, in which the gall scales were found to have formed on *Cupressus*,[31] the hypertrophy being due to a chalcid fly.

ZOOLOGY.—*On the morphology of* Deontostoma californicum *n. sp.* (*Leptosomatinae, Nematodes*).[1] G. STEINER and FLORENCE M. ALBIN, Bureau of Plant Industry.

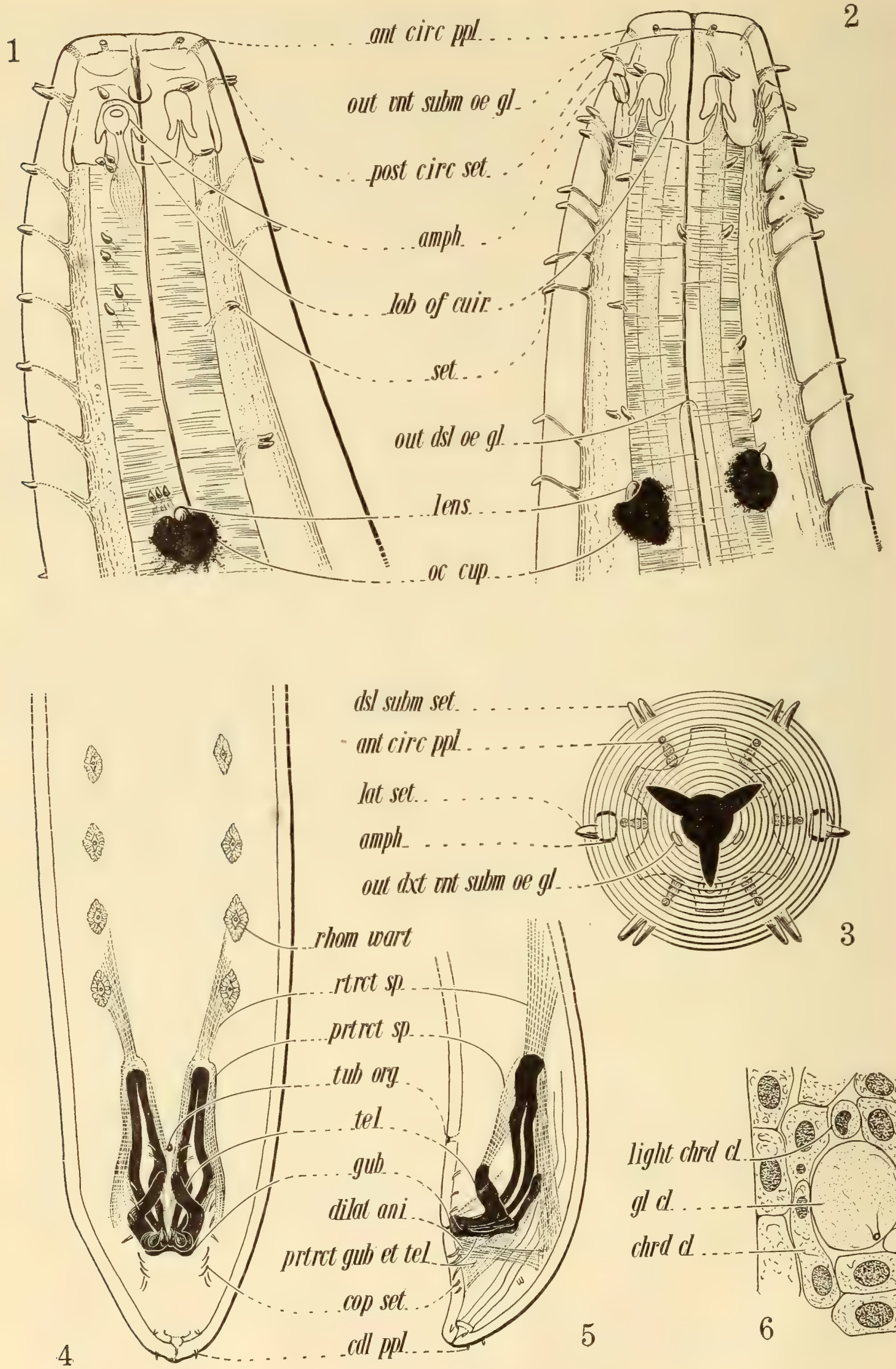
A single male specimen of *Deontostoma californicum* n. sp. was referred to the senior writer for identification by the U. S. National Museum, Washington, D. C. The specimen was collected by Mr. E. F. Ricketts at Pacific Grove, California, and is the first representative of this group of nemas to be described from the Pacific coast. Approximately half a dozen species of this genus are at present known. They all belong to a group of the largest of free-living nemas as yet described. *Deontostoma californicum* is of filiform shape, the head broadly truncate, the tail of the male conical with the end obtusely rounded. The top layer of the cuticle exhibits fine cross fibers. Fig. 6 represents a portion of one of the lateral chords, which consists of three to four series of at least three different kinds of cells; first, the normal chord cells; second, the lateral chords which contain cells that are distinguished from the chord cells proper by a somewhat lighter color and the slightly sausage-shaped nucleus (Fig. 6); and third, large glandular cells with an outlet rather close to the dorsal edge of the chord. Such glands are also found in related species and genera. Their significance is not known. Some investigators consider them perhaps excretory in function, but this supposition is doubtful. The only fact supporting this view is the possible absence of a ventral gland or renette cell and its outlet. Beginning in the region of the nerve-ring these glandular cells are seen at quite regular intervals all along the lateral chords almost to the tail end.

The ventral chord is also well developed (Fig. 7).

Numerous short conical setae are seen in the region anterior to the nerve-ring. They closely resemble the cephalic setae and are arranged

[31] Chaney, R. W., and Mason, H. L., Carnegie Inst. Publ. 415, p. 11, pl. 7, figs. 4–9, 1930.

[1] Received August 30, 1932.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more or less distinctly in longitudinal series,—lateral, submedial, and medial (Figs. 1 and 2). To what extent their number and position is constant is not known. Special mention should be made of a group of three, side by side, just in front of each ocellum. Caudad of the nerve-ring, the setae are replaced by fine nerve fibers, penetrating the cuticle and sometimes ending in a tiny hair (Fig. 7). However, they are much less numerous than those farther cephalad.

The head has the circles of papillae and setae typical for the genus. Their arrangement and shape is much like that of *D. antarcticum* (deMan) Filipjev (=*Thoracostoma antarcticum* deMan[2]): six papillae in an anterior and ten setae in a posterior circle. The anterior ones do not protrude above the surface (Figs. 1 and 2) but can well be seen penetrating the cuticle in front of the cuirass.

The form and position of the amphids may be seen in Figs. 1, 2, and 3, being essentially the same as in *D. antarcticum.* A small, transverse, oval opening leads into a cavity almost lemon-shaped (Fig. 1), at the inner and posterior wall of which the amphidial nerve connects. Terminals have not yet been seen; the only notable structures observed are two small, rodlike, cuticular thickenings at the base of the cavity. The amphidial nerve is surrounded by a narrow tube which soon widens to a spindle-shaped cavity containing what appears to be the usual sensillar structures.

A front view of the head end reveals the presence of three lips and a very small pharynx with no armature. The subdermal cuticular

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Figures 1-6

Fig. 1. *Deontostoma californicum* n. sp. Head end, lateral view, male, and

Fig. 2. Same, dorsal view, *amph,* amphid; *ant circ ppl,* anterior circle of papillae; *lens,* lens; *lob of cuir,* lobe of cuirass; *oc cup,* eye cup; *out dsl oe gl,* outlet of dorsal oesophageal gland; *out vnt subm oe gl,* outlet of ventrosubmedial oesophageal gland; *post circ set,* posterior circle of setae; *set,* setae. ×720.

Fig. 3. Front view of head. *amph,* amphid; *ant circ ppl,* anterior circle of papillae; *dsl subm set,* dorsosubmedial setae; *lat set,* lateral setae: *out dxt vnt subm oe gl,* outlet of dextroventrosubmedial oesophageal gland. ×1090.

Fig. 4. Male tail, ventral view, and

Fig. 5. Same, lateral view. *cdl ppl,* caudal papillae; *cop set,* copulatory setae; *dilat ani,* dilatator of the anus; *gub,* gubernaculum; *prtrct gub et tel,* protractor gubernaculi et telamonis; *prtrct sp,* protractor spiculi; *rhom wart,* rhomboid wart; *rtrct sp,* retractor spiculi; *tel,* telamon; *tub org,* tubular organ. ×120.

Fig. 6. Portion of left lateral chord. *Chrd cl,* chord cell; *gl cl,* gland cell; *light chrd cl,* light colored chord cell. ×1090.

[2] DeMan, J. G., Nematodes libres: Expédit. Antarctique Belge. Résultats du Voyage du S. Y. Belgica en 1897–1898–1899, Zoologie Anvers., pp. 51, 1904.

structure, commonly called a cuirass, is almost as wide anteriorly as posteriorly. The six lobes are all of similar shape and size (Fig. 3); they are not perforated.

The cylindrical, strongly muscular oesophagus has a yellowish brown pigmentation posterior to the eyespots. This latter is different from, and has nothing to do with, the dark, carmine colored pigment that forms the eye cups. These are not at the same level on both sides, the left one being slightly more caudad. It might be said that some of the carmine pigment is "scattered" outside the proper pigment cups.

The arrangement of the oesophageal glands is the same as in *D. antarcticum*. As may be seen in Fig. 2, the outlets of the ventrosubmedial glands occur at about the anterior rim of the head cuirass while the dorsal one (Fig. 2) empties a short distance in front of the ocelli.

The spicular apparatus of the male consists of three kinds of elements: first, the spicula, paired, comparatively long, sharply curved at the beginning of their distal third; second, an apparently single gubernaculum, slender, not quite half the length of the spicula, dorsal in its position and flat and wide in its distal portion; and third, a pair of knee-shaped telamon-like pieces, one on each side of the distal part of the spicula, forming a pointed angle if seen in side view, and fronting the spicula on their ventral side. The muscles moving this rather complicated apparatus are partly sketched in Figs. 4 and 5. A point for special attention is the connecting muscle between the proximal end of the telamon and the proximal end of the related spiculum, suggesting a high correlation in their copulatory movements. This spicular apparatus clearly differentiates the present species from all other members of the genus as yet described.

The bursal muscles are very numerous and extend far forward (Fig. 7). Strong circular muscle fibers are seen all along the ejaculatory duct (Fig. 7).

The tubular, ventromedian outlet apparently common to males of all species of the genus has a position similar to that in *D. antarcticum*, that is about even with the middle of the spicula (Figs. 4, 5, and 7). It is supposed to be the outlet of a gland, but in this nema the gland has not yet been seen, perhaps because of the opaque condition of this portion of the body. A somewhat irregular series of eleven stiff setae is seen on each side of the anal opening, beginning anteriorly as far forward as the aforementioned tubular gland outlet and ending posteriorly about halfway down the tail (Figs. 4 and 5). The number and arrangement of these setae seem to be characteristic of the pres-

ent species. Cephalad of the spicula a third group of accessory male copulatory organs is present; on each side there is a ventrosubmedian series of four rhomboid, warty structures (Figs. 4 and 7) each with what appears to be a central pore or seta. The wart itself does not seem to be a part of the cuticle but to consist of secreted substance. The region in front of and around these warts and some of the latter themselves were covered with another kind of coagulated sticky substance suggesting a secretion produced during copulation for cementing the male to the female and only partly loosened or dissolved at the time this specimen was fixed. Its position would rather suggest a secretion through the pores (?) of the warts. On the other hand, the ventromedian tubular outlet, found in other species to be connected with a gland, may be its proper source. It is difficult, however, to see how such a mass of substance as seen here could all have originated from this one source.

As sketched in Figs. 4 and 5 there are short setaceous papillae on the tail, some close to the terminus, that are not connected with the sexual apparatus. The terminus is perforated by the so-called spinneret or outlet of the caudal glands, which, in turn, are found in front of the spicular apparatus and connect with the outlet by long tubular canals.

7

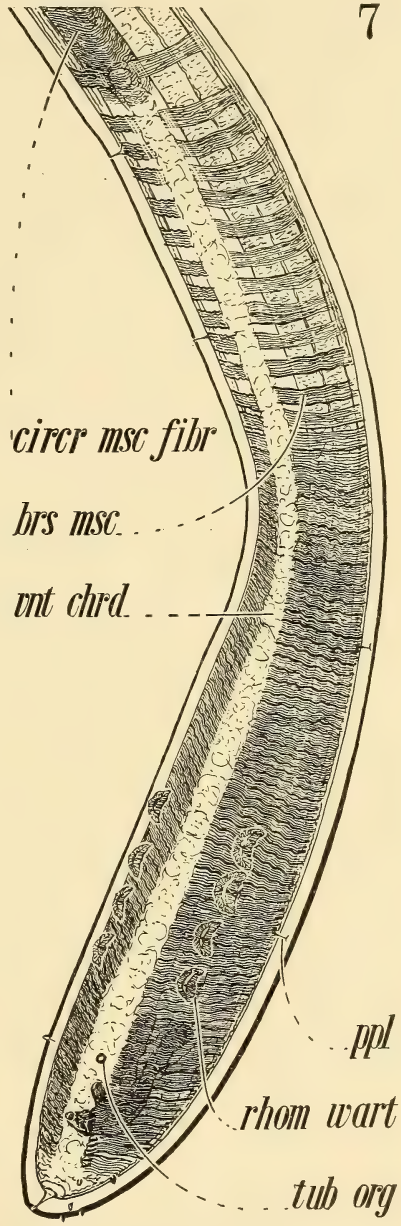


Fig. 7. *Deontostoma californicum* n. sp. Male tail, lateral view showing bursal muscles. *brs msc*, bursal muscle; *circr msc fibr*, circular muscle fibers of ductus ejaculatorius; *ppl*, papillae; *rhom wart*, rhomboid wart; *tub org*, tubular organ; *vnt chrd*, ventral chord. ×85.

Measurements:

Pharynx		Oesophagus	M	Anus	
0.2	——	12.0	50.0	99.0	15.2 mm.
0.3	——	1.4	1.8	1.2	

Diagnosis: Deontostoma with ocelli and a large number of short setae in the region anterior to the nerve-ring. Cuirass with six equal, imperforate, anchor-shaped lobes. Pharynx almost none; no armature. Spicular apparatus consisting of spicula, single gubernaculum, and knee-shaped telamon. On each side of the anus of the male an irregular series of eleven setae. Ventromedian tubular outlet level with the middle of the spicula. Four rhomboid wartlike ventro-submedian structures in front of the spicula.

ZOOLOGY.—*A North American species of* Acetes.[1] H. J. HANSEN, Copenhagen. (Communicated by WALDO SCHMITT.)

The very interesting genus *Acetes*, established in 1830 by H. Milne-Edwards on a single Indian species, belongs to the Sergestidae, the lowest, or, as may be said, the most primitive family among Crustacea Decapoda. The genus comprises scarcely a dozen species, the majority of which live in the Indian Ocean and the adjacent tropical areas of the Pacific, yet a single species goes so far northward as Korea. From the Atlantic only three species have hitherto been known, all South American forms, viz.: two species from Brazil and the third from a lagoon at Rio Paraguay, near its junction with Rio Parana. (A single specimen of the last-named form was also taken "in the outlet of Riacho del Oro in Rio de la Plata in feebly brackish water.") The discovery of a new Atlantic species secured as far northward as Beaufort, N. C. (about lat. 34° 47′ N.) seems interesting.

In the report "The Sergestidae of the Siboga Expedition"[2] the present writer reviewed the genus *Acetes*, describing not only the species taken by the Dutch expedition but also other forms preserved in the Copenhagen Museum, and among these two species from the western side of South America. Besides, the species mentioned in the literature, but unknown to me, were enumerated. Unfortunately, I did not know that Stanley Kemp in his series, "Notes on Crustacea Decapoda in the Indian Museum," had published an excellent paper, "The genus *Acetes* Milne-Edwards,"[3] in which he described and gave

[1] Received Oct. 20, 1932.

[2] Siboga Exp., vol. 38, 1919.

[3] Records of the Indian Museum, vol. 13, pp. 43–58, 1917.

analytical figures of four species, one of which was new. Disturbed conditions owing to the great war delayed the receipt of this paper.

In my "Report" mentioned above a somewhat detailed diagnosis of the genus *Acetes* was given. Under "remarks," I added several statements, some of which may be quoted here.

"The genus *Acetes* differs from *Sergestes* in several characters: The maxillulae and the first maxillipeds without palp, the maxillae with undivided lobe, first pair of legs with a short chela as the two following pairs, fourth and fifth pairs of legs wanting excepting the coxae of (probably) fifth pair in the male, finally only five pleurobranchiae above third pair of maxillipeds and the thoracic legs. In the absence of two pairs of thoracic legs *Acetes* agrees with *Lucifer*, but otherwise it is far removed from this peculiar genus and related to *Sergestes* and *Sicyonella*."

"The males show excellent specific characters in the relative length of third joint of the antennulae, in the joints of the lower antennular flagellum, and especially in the structure of [the] clasping organ, finally in the structure of the petasma. In the females the ventral area at and behind the base of the last pair of legs affords most useful characters. The females are on the whole somewhat or even considerably larger than the males."

The new form is closely allied to *Acetes brasiliensis* Hansen.[4] The following descriptions of both sexes are worked out to facilitate comparison of the two species.

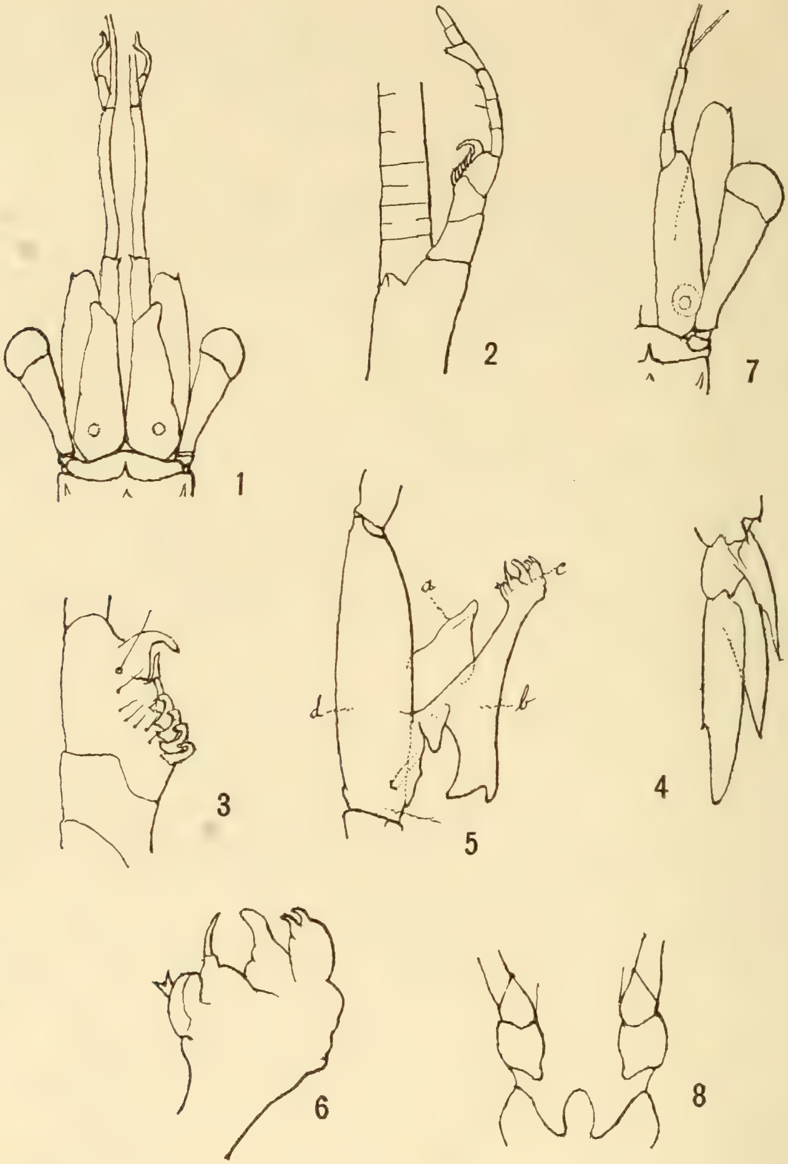
Acetes carolinae, new species

(Figs. 1–8)

Male.—The anterior keel of the carapace has, as in *A. brasiliensis*, only a single tooth, as the denticle, which in most forms exists between that tooth and the rostrum, has disappeared. The rostrum is short with the end acute. Transverse diameter of the eye a little more than one third as long as the distal joint of the stalk with eye.

Antennulae with the peduncle long (Fig. 1); its third joint very elongated, distinctly curved, almost two and one half times as long as the inner margin of second joint. Lower flagellum (Fig. 2) somewhat longer than the inner margin of second peduncular joint; its thickened 3-jointed proximal portion occupies a little less than half of the flagellum. The inner (upper) margin of the third joint is convex and from near its base to considerably beyond its middle the joint has on its inner surface near the margin mentioned a close row of 6 spines, of which the proximal ones have the distal half very curved with the end obtuse (Fig. 3), while the curvature is much feebler on the fifth spine, and the sixth spine is nearly straight, acute. Close beyond the sixth spine and somewhat before the end of the joint, the upper margin possesses on its inner side a large, claw-shaped process which is very broad at the base, while its more distal portion is only moderately robust and extremely recurved. The distal part of the flagellum is slender, 6-jointed, with an oblique and distally obtuse short process on the distal half of the antepenultimate joint (Fig. 2).

[4] Siboga Exp., vol. 38, p. 48, 1919.



Figures 1–8. *Acetes carolinae*, new species.

Fig. 1. Anterior part of carapace with eyes, antennulae, and antennal squamae of a male, ×12. Fig. 2. Distal part of right antennular peduncle with proximal part of upper flagellum and the whole lower flagellum of a male, from the outer side, ×47. Fig. 3. Major distal part of the thickened portion of the lower flagellum seen in fig. 2, from the inner side, ×ca. 150. Fig. 4. Left uropod and telson of a male, ×14. Fig. 5. Right petasma, from in front, ×30: *a*, pars externa; *b*, pars media; *c*, capitulum; *d*, peduncle of first abdominal leg. Fig. 6. Capitulum of the petasma shown in fig. 5, ×114. Fig. 7. Right half of the front part of the carapace with appendages of a female, from above, ×21. Fig. 8. Proximal portions of third pair of legs and the genital area of a female, from below, ×21.

The antennal squama (Fig. 1) does not reach the distal end of the second antennular joint. Coxae and trochanters of third pair of legs without a tooth at their distal inner angle. Genital coxae very obliquely triangular, but much broader than long and distally very broadly rounded. Exopod of uropods (Fig. 4) about five times as long as broad; the ciliated part occupies somewhat more than one third of the outer margin, and a minute tooth is seen at the end of the glabrous part.

The petasma (Fig. 5) is in most features rather similar to that in *A. brasiliensis,* but it is sharply distinguished by shape and armament of the capitulum. Pars astringens is completely wanting. Pars externa (*a*) much smaller than in *A. brasiliensis,* considerably longer than broad, with its distal free part triangular and a little longer than broad. Pars media (*b*) is rather slender; its free proximal portion is considerably longer than broad with the outer margin concave, while the basal margin is somewhat deeply and obliquely concave, with the inner proximal corner produced into a somewhat short, subacute process, and the outer corner much larger, subacute. Beyond the insertion of pars externa, pars media is long and narrows greatly to the thickened capitulum (*c*). The capitulum is subglobular and produced along the outer margin into four lobes; the proximal lobe is moderately short, thick, rounded, with a small chitinous bifid plate at the outer side; the second lobe is triangular, broader than long, but terminates in a long, strong, slightly curved spine; the third lobe is longer than broad, with its distal half shaped as a somewhat curved, moderately slender protuberance, with obtuse end; the fourth lobe is somewhat longer than broad, ovate, with two somewhat small, curved, acute, spiniform processes on the end.

Length.—11.5 mm.

Female.—Rostrum and crest as in the male. Eyes as in the male. Antennulae (Fig. 7) with the peduncle very much shorter than in the male, but the first joint is slightly shorter than eye-stalk with eye, thus slightly shorter than in the male. Second joint proportionately very much shorter than in the male, a little more than half as long as the third joint, which is straight and conspicuously more slender than in the other sex. Lower flagellum even slightly longer than third joint of the peduncle, slender, and apparently seven-jointed.

The antennal squama reaches to or slightly beyond the middle of third antennular joint. Coxae of third pair of legs (Fig. 8) with the major part of the inner margin convex and no tooth below or at the end, while the proximal inner corner is produced into an obtuse protuberance.

The genital area (Fig. 8) is moderately long, broad; the median part of its posterior margin is very strongly procurved, constituting a bend which is conspicuously longer than broad and obtuse at the base in the middle; this curious structure is due to the fact that each sublateral part of the genital area is produced posteriorly into a proportionately long, obliquely triangular, distally sacciform and quite free protuberance with the end obtuse.

Length.—15 mm.

Remarks.—*A. carolinae* is closely allied to *A. brasiliensis,* as the differences in most features are small, but the lobes of the capitulum of the petasma afford striking characters between the males of the two species, while the shape of the genital area exhibits excellent differences between their females.

Occurrence.—A large number of specimens were sent to me by Dr. James S. Gutsell, of the Beaufort, North Carolina, laboratory of the U. S. Bureau of Fisheries, who wrote: "All were collected in a trawl net near the Sea Buoy off Beaufort Inlet, October 30, 1929." And in a later letter he writes: "With

bobbinet around the tip of an otter trawl this *Acetes* sometimes is obtained in gallons at a time, especially in late summer and early fall."

ZOOLOGY.—*The eggs of* Goniobasis virginica *Gmelin and* Anculosa carinata *Bruguière.*[1] CHARLES P. WINSOR, Johns Hopkins University. (Communicated by RAYMOND PEARL.)

So far as I know the eggs of these two species have never been reported. Jewell[2] has described the eggs of *G. liviscens correcta,* and Van

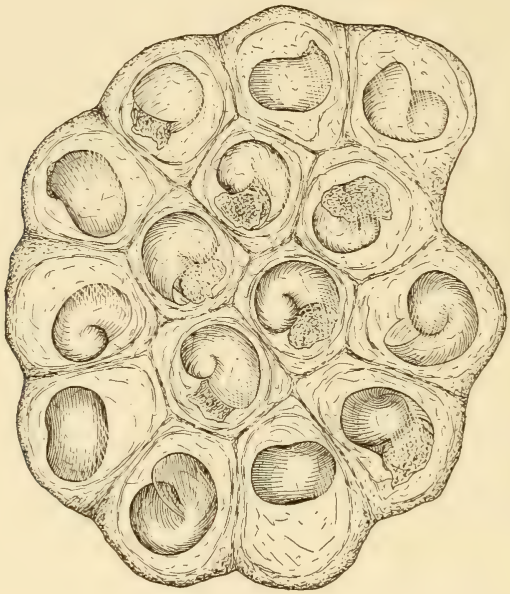


Fig. 1.—Egg mass of *Goniobasis virginica.* ×36.

Cleave[3] has described the eggs and egg-laying habits of species of *Pleurocera Lewisii* and *P. acuta.*

During June of this year several trips were made to Gunpowder Falls, a stream about 15 miles north of Baltimore, in which *G. virginica* and *A. carinata* are abundant. (A description of the locality

[1] From the Department of Biology of the School of Hygiene and Public Health of the Johns Hopkins University. Received September 23, 1932.

[2] Jewell, Dorothea Dodd, Observations on reproduction in the snail *Goniobasis:* Nautilus, vol. 44, pp. 115–119, 1931.

[3] Van Cleave, H. J., Studies on snails of the genus *Pleurocera.* I. The eggs and egg-laying habits: Nautilus, vol. 46, pp. 29–34, 1932.

will be found in a paper by Baily, Pearl, and Winsor.)[4] An examination of the rocks in the stream-bed showed large numbers of egg-masses, which proved in the laboratory to be those of *G. virginica.* Further search on the rocks in mid-stream showed numerous egg-capsules of a different type, obviously those of *A. carinata.*

The eggs of *G. virginica* are laid in masses of from two to fifteen or more, attached to the rocks in the stream bed. The egg mass, as may be seen from Fig. 1, resembles closely that of *Pleurocera* as described and figured by Van Cleave. The spiral arrangement of the eggs in the egg mass of *G. virginica* is generally marked. There is a fairly tough outer membranous covering, which forms septa dividing the mass into compartments. Within each of these is a much thinner egg-membrane, enclosing the albumen and embryo. A considerable amount of foreign matter is generally rather firmly attached to the mass.

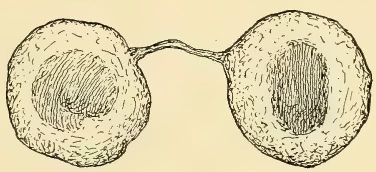


Fig. 2.—Eggs of *Anculosa carinata.* ×36.

The eggs of *A. carinata* resemble generally those of *G. liviscens* as described by Jewell. They are laid separately, usually in lines of three

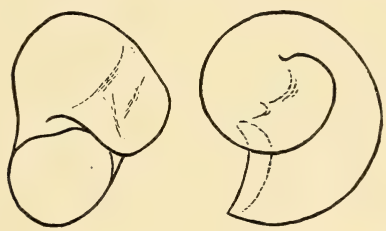


Fig. 3.—Young shell of *Goniobasis virginica.* ×72.

to six or more; the successive capsules may be connected by a thread-like portion of the outer membrane. The capsules are circular or slightly elliptical, flat against the rock and convex on the outer side. A thin egg-membrane surrounds the albumen and embryo. The outer

[4] Baily, Joshua L., Jr., Pearl, Raymond, and Winsor, C. P., Variation in *Goniobasis virginica* and *Anculosa carinata* under natural conditions: Biologia Generalis, vol. 8, pp. 607–630, 1932.

surface of the capsule is granular owing to the sand grains that adhere to it. (Compare Van Cleave's description of *Pleurocera* eggs.)

No data are available on the duration of embryonic development for either species, though it is probably not widely different from the $11\frac{1}{2}$ days reported by Jewell. Figure 3 shows a young specimen of *G. virginica* hatched in the laboratory; Figure 4 shows a young *A. carinata* found in the river; unfortunately none of the eggs brought in hatched.

Fig. 4.—Young shell of *Anculosa carinata.* ×72.

All of the drawings in this paper were made by the staff artist of this department, Mr. Arthur Johansen, with a camera lucida.

CHEMISTRY.—*The rotenone content of derris root, cube root, and other plant materials.*[1] HOWARD A. JONES, Bureau of Chemistry and Soils. (Communicated by C. M. SMITH.)

Rotenone, a constituent of derris root (*Deguelia* sp.) and of cube root (*Lonchocarpus nicou*), has recently come into prominence as an insecticide of considerable value. An extraction method[2] making use of carbon tetrachloride was recently outlined by the author for the determination of this compound in plant materials. The present article gives the results obtained by this method, and by an ether extraction method previously in use, in the analysis of plants of the genus *Deguelia* from the Malay Peninsula and the East Indies, and plants of the genus *Lonchocarpus* from South America.

Rotenone has been previously reported as occurring in species of both of these genera of plants. Nagai[3] was the first to isolate rotenone from a species of *Deguelia,* the roots of *D. chinensis.* By ether extraction of the roots of *D. elliptica,* Kariyone and Atsumi[4] obtained 6.65

[1] Received October 12, 1932.
[2] Ind. Eng. Chem., Anal. Ed., vol. 5, no. 1, Jan. 15, 1933.
[3] Jour. Tokyo Chem. Soc., vol. 23, p. 744, 1902.
[4] Jour. Pharm. Soc., Japan, no. 491, p. 10, 1923.

per cent crude rotenone; while Takei,[5] also using ether, found the rotenone content of several samples of roots of the same species to range from 1.5 to 6 per cent. Recently Spoon[6] has analyzed a number of samples of roots of species of *Deguelia* by the ether extraction method outlined by Roark.[7] He found that *D. elliptica* ranged in rotenone content from traces up to 6 per cent, and *D. malaccensis* contained from traces up to 2 per cent. A number of commercial samples of derris root of unknown species he found contained from no rotenone up to 6.5 per cent.

The rotenone content of stems of *Lonchocarpus nicou* from French Guiana was reported as 2 to 2.5 per cent by Geoffroy,[8] who used a petroleum ether extraction, as early as 1895. Clark,[9] by ether extraction, recently obtained 7.1 and 7.2 per cent rotenone from two samples of cube root (*L. nicou*) from Peru.

Spoon[10] has also determined the amount of rotenone in both the stems and roots of nekoe (an unidentified species of *Lonchocarpus* from Dutch Guiana) by the ether extraction method used for derris roots. He found that the root averaged about 2.5 per cent rotenone, while a sample of stem material contained only 0.03 per cent. Rotenone has been reported by Tattersfield, Gimingham and Morris[11] as occurring in haiari stems and roots (a species of *Lonchocarpus* found in British Guiana) "in fairly considerable quantities." Pfaff[12] has reported "timboin," which appears to have been impure rotenone, in Brazilian timbo root (probably a species of *Lonchocarpus*).

One of the objects of this investigation was to obtain a comparison of the ether extraction method, previously in use by the Insecticide Division of this Bureau, with the carbon tetrachloride method recently developed. As a result of the analyses reported in this paper the latter method has been adopted. A further purpose of the present work was to determine the variation in the rotenone content of derris root, cube root and other plant materials, and to ascertain the desirability of these materials as sources of supply of rotenone.

Of the samples of derris root tested, three were authentic speci-

[5] Bul. Inst. Phys. Chem. Research (Tokyo), vol. 2, p. 485, 1923.

[6] Indische Mercuur, vol. 54, no. 18, p. 351, 1931, and vol. 55, no. 13, p. 181, 1932.

[7] Soap, vol. 7, p. 97, 1931.

[8] Ann. Inst. Colon. Marseille, vol. 2, p. 1, 1895.

[9] Science, vol. 70, p. 478, 1929.

[10] Indische Mercuur, vol. 54, no. 49, p. 1043, 1931.

[11] Ann. Appl. Biol., vol. 13, p. 424, 1926.

[12] Arch. der Pharmacie, vol. 229, p. 31, 1891.

mens of *D. elliptica* and two were authentic *D. malaccensis*.[13] Unfortunately the remaining samples analyzed were received merely under the name of "derris root" or "tuba root" and were of unknown species. In many cases the original source was also unknown. Since the majority of the root in commerce is said to be *D. elliptica*, it is probable that many of the samples bought in the open market were of this species. All samples of derris root were found to conform in histological elements[14] to an authentic sample of *D. elliptica* and hence are almost certainly of the genus *Deguelia*.

One sample of authentic *L. nicou* was obtained (under the name of "barbasco" or "cube") from the Field Museum of Natural History in Chicago. Other specimens of cube and barbasco roots were compared with this sample and found to be identical in histological elements. All samples of cube or barbasco roots were obtained from Peru and, according to Killip and Smith,[15] these native terms are restricted, in that region, to *L. nicou*.

A sample of timbo root obtained from Brazil was stated to be *Paullinia pinnata*, but from the findings of Killip and Smith, it is more likely that this material is a species of *Lonchocarpus*. This is borne out by the fact that this sample closely corresponded in histological elements to an authentic sample of *L. nicou*. One sample of nekoe stems from Dutch Guiana and two samples of haiari stems from British Guiana were analyzed.

The results of the extractions are given in the tables, in which the samples have been divided into three groups; roots of the genus *Deguelia*, roots of *L. nicou*, and samples of other plants of the genus *Lonchocarpus*. The numbers are Insecticide Division sample numbers and are given merely for convenience in referring to the samples. Values for both rotenone and total extractive material are given for both methods. (In a number of cases the sample was analyzed by only one method.) In the majority of cases the results given represent the mean of two or more determinations. All results are based on the weight of air-dried material, the moisture content of all samples at the time of analysis being between 2 and 5 per cent. A few samples received in a more moist condition than this were dried to within this

[13] Two samples of *D. elliptica* roots and two of *D. malaccensis* roots were obtained through the courtesy of the Department of Agriculture of the Federated Malay States and Straits Settlements.

[14] The cooperation of George L. Keenan of the Food and Drug Administration, U. S. Department of Agriculture in making microscopic examinations is gratefully acknowledged.

[15] This JOURNAL, vol. 20, p. 74, 1930.

range before grinding. All roots not otherwise designated in Table I were bought on the open market in this country and were of unknown original source.

TABLE I. Roots of Deguelia species (derris root)

Sample Number	Carbon Tetrachloride Method		Ether Method		Remarks
	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	
401	None	9.4	None	9.8	Included some stem and leaf parts. Bought in Holland.
402	1.4	7.6	1.0	8.2	
406	None	16.3	None	14.8	Java, Dutch East Indies.
407			3.0	16.0	
408	2.0	19.6	None[a]	20.0	
411	0.9	9.4			
412	None	22.6	None[b]	19.6	
502			0.8	5.4	
522	6.7	22.2	6.8	21.6	Shipped from Singapore.
523	1.4	13.6	1.4	12.2	*D. elliptica* (Tuba Puteh) Malayan Govt. Exp. Plantn., Serdang, F.M.S.
524	1.8	21.0	None[a]	22.6	*D. malaccensis* (Tuba standing) Malayan Govt. Exp. Plantn., Serdang, F.M.S.
535	4.5	20.7	4.3	17.9	
537	1.9	20.8	None[a]	23.4	Dutch East Indies.
547			About 0.4	14.3	Federated Malay States.

[a] No rotenone separated even when seed crystals were used.

[b] 2 to 3 per cent amorphous material separated from the ether extract, but no rotenone was detected in this.

TABLE I. (*Continued*).

Sample Number	Carbon Tetrachloride Method		Ether Method		Remarks
	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	
548	About 0.1	20.6	—[c]	19.2	Sumatra, Dutch East Indies.
549	1.9	17.8	2.0	16.8	Federated Malay States.
550			0.6	13.0	
585	None	—[d]	None[e]	12.1	Bought in Holland.
586			1.5	16.2	
588-A	0.6	11.9	About 0.3	10.0	
588-B			2.2	9.9	
588-C			3.2	15.9	
588-D			3.0	12.2	
588-E	1.0	11.4	About 0.4	9.4	
588-F			1.9	10.4	
594 (A) coarse	3.4	12.3	3.0	12.4	Shipped from Singapore.
594 (B) fine	6.0	19.1	5.9	18.9	
594 Aver. whole root[f]	5.2	17.1			
611			1.6	15.9	Shipped from Singapore.
612			1.7	9.5	Shipped from Singapore.
621	2.4	19.2	1.0	18.2	
626			0.9	16.3	

[c] About 2 per cent material separated from the ether extract; this was found to contain only a very small proportion of rotenone.

[d] Total carbon tetrachloride extract not determined.

[e] About 0.6 per cent material separated from the ether extract, but no rotenone was detected in this.

[f] This average is based on the proportion of fine and coarse roots comprising the whole root sample.

TABLE I. (*Continued*)

Sample Number	Carbon Tetrachloride Method		Ether Method		Remarks
	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	
685			3.0	14.6	
739	1.7	15.6	None[a]	14.6	Shipped from Singapore.
741	1.8	9.3	1.3	8.8	*D. elliptica* Malayan Govt. Exp. Plantn., Serdang, F.M.S.
742	2.1	24.0	1.2	24.7	*D. malaccensis* Malayan Govt. Exp. Plantn., Serdang, F.M.S.
(A) coarse 743(B) fine Aver. whole root[f]	2.0 2.3 2.1	15.5 16.3 15.8	0.3 0.4	15.2 17.1	*D. elliptica* F.M.S.
765	6.3	21.4	5.5	20.2	
875	2.9	12.0			Shipped from Singapore.
956	6.9	21.4			
998	None	15.4			Sumatra, Dutch East Indies.
999	None	13.7			Sumatra, Dutch East Indies.
1000	None	16.5			Sumatra, Dutch East Indies.
1001	5.7	16.8			Shipped from Singapore.
1002	5.3	16.7			Shipped from Singapore.

[a] No rotenone separated even when seed crystals were used.

[b] This average is based on the proportion of fine and coarse roots comprising the whole root sample.

TABLE I. (*Continued*)

Sample Number	Carbon Tetrachloride Method		Ether Method		Remarks
	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	
1003	6.1	17.4			Federated Malay States.
1004	4.2	15.1			Federated Malay States.
Average[g]	2.5	16.5			

[g] This average is for 31 samples analyzed by the carbon tetrachloride method. No. 585 is not included in the average because no determination of total extract was made on this sample. The average values for whole root of Nos. 594 and 743 were used in obtaining the final average.

TABLE II. Roots of Lonchocarpus nicou (cube root)

Sample Number	Carbon Tetrachloride Method		Ether Method		Remarks
	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	
425			1.4	12.2	
426	0.8	6.1	None[a]	4.1	
427	1.8	12.0	1.4	11.1	
433	6.8	20.0			"Barbasco or Cube" from Field Museum of Natural History, Chicago. Authentic *L. nicou.*
527	1.3	9.2	1.6	9.5	
583	6.1	16.5	6.1	16.0	
584	6.0	18.5	6.1	17.6	
674	1.5	13.8	2.0	13.7	
686-A	11.2	24.3	11.0	23.8	
686-B	6.7	14.8			
686-C	4.0	12.2	5.0	10.8	
686-D	8.5	18.2			

[a] No rotenone separated even when seed crystals were used.

TABLE II. (*Continued*)

Sample Number	Carbon Tetrachloride Method		Ether Method		Remarks
	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	
686-E	7.4	17.2	7.2	15.9	
686-F	5.5	13.4			
686-G	6.3	15.0	6.3	13.8	
686-H	5.6	12.9			
686-I	6.1	14.3	5.8	14.4	
740	3.9	13.3			
821	4.1	16.7	3.6	15.6	
867	3.4	12.9			
940-A	8.6	20.2			
940-B	6.1	13.7			
1025	8.0	22.4			Received as "Barbasco Root."
Average[b]	5.4	15.3			

[b] This average is for the 22 samples analyzed by the carbon tetrachloride method.

TABLE III. OTHER PLANTS OF THE GENUS LONCHOCARPUS

Sample Number	Plant Material and Source	Carbon Tetrachloride Method		Ether Method	
		Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)	Rotenone (per cent of air-dried material)	Total Extract (per cent of air-dried material)
409	Timbo Roots—Brazil	About 5[a]	28.0		
434	Haiari stems	None	2.6	None	2.8
627	Haiari stems—British Guiana	1.0	6.2	None[b]	6.6
990	Nekoe stems—Dutch Guiana	About 0.4	3.5		

[a] 6 to 7 per cent material separated, but this was found to be only partly rotenone; value given for rotenone estimated from examination of separated material.

[b] No rotenone separated even when seed crystals were used.

Some of the advantages of the carbon tetrachloride extraction method over the method using ether are clearly illustrated by the results in the tables. For instance, in the cases of derris root samples 408, 524, 537 and 739, cube root sample 426 and haiari stem sample 627, no rotenone was obtained by the ether method even when the evaporated extract was seeded with rotenone crystals. On the other hand, between about 1 and 2 per cent rotenone was obtained by the carbon tetrachloride extraction of these same samples. Decidedly lower values for rotenone were obtained by the ether method in the cases of derris roots 588-E, 621, 742 and 743. Furthermore, the ether extracts of three derris root samples (412, 548 and 585) yielded varying amounts of material which was found to contain either no rotenone, or, in the case of 548, only a small proportion of rotenone. The carbon tetrachloride extracts of these three samples gave no separation of material, or, in the case of 548, only about 0.1 per cent rotenone. The ether extraction values for rotenone given in the tables are therefore not reliable.

Perhaps the most striking observation to be made is the wide range in the rotenone content of both derris and cube roots. Thus the rotenone in derris root ranges from none to almost 7 per cent, and that in cube (or barbasco) root from less than one to about 11 per cent. This variation is probably due in part to differences in age, size of roots, soil conditions and other factors. In the case of the derris root samples the variation is no doubt partly due to differences in species.

An examination of the values for rotenone and total extract of derris root shows that there is little or no correlation between either the total carbon tetrachloride extractives or the total ether extractives and the rotenone content. Good correlation could hardly be expected since the samples are of different species and from different sources. However, there is a comparatively close correlation between the total carbon tetrachloride extractives and rotenone in the cube root samples, the coefficient of correlation being 0.86. Such a correlation is, no doubt, due to the fact that the cube samples are all of the same species (*L. nicou*) and all from the same region. The values for total ether extract and rotenone content of cube roots also show a fairly good correlation. However, the calculation of the rotenone content of a sample of cube root from the amount of total extract would give only approximate results.

As will be noted, the two authentic samples of *D. malaccensis* tested contained only about 2 per cent rotenone, in spite of their high total

extract values. This agrees with the results of Spoon (loc. cit.) on this species. It is possible that some of the other samples of derris root having high total extracts were also of this species.

According to Georgi[16] who has made a study of the proportion of ether extractives obtained from coarse and fine roots of *D. elliptica* and *D. malaccensis* of different ages, the ether extract content of fine roots is higher than that of coarse roots. It was thought of interest to determine whether this was also true of the rotenone content. Accordingly two samples of derris root (594 and 743) were separated into fine and coarse roots and analyzed separately. Roots smaller than 4.0 to 4.5 mm. in diameter were arbitrarily considered "fine" and those of this size and over were designated as "coarse." The fine roots constituted about 71 per cent of the whole root in the case of No. 594 and about 32 per cent in the case of No. 743. It will be seen from Table I that in both samples the rotenone content (by the carbon tetrachloride method) of the fine roots was higher than that of the coarse roots.[17] This was also true of the total extractive materials.

Some idea of the variation to be expected in single shipments of both derris and cube roots is afforded by the results in the table. Thus samples 588-A to 588-F, inclusive, were taken from six 80 to 100-pound bales of a single shipment of derris root. As will be noted the rotenone content ranges from a few tenths of one per cent to about 3 per cent. Similarly samples 686-A to 686-E were taken from five 65 to 100-pound bales of a single shipment of cube root. The lowest rotenone content found in this shipment was 4 per cent while the highest was about 11 per cent. Samples 686-F to 686-I are from four bales of a second consignment of this shipment. Samples 940-A and 940-B of cube root were also from a single shipment. This variation in single shipments should emphasize the necessity of careful sampling of shipments of root for analysis.

The high rotenone content of the timbo root tested indicates that this material merits further study as a possible source of rotenone. The low values for total extractives obtained from haiari and nekoe stems are interesting. Spoon (loc. cit.) obtained about 2.5 per cent ether extractives from nekoe stem, which indicates that these materials are consistently low in total extract.

A more systematic study of the rotenone content of authentic samples of the numerous species of *Deguelia* and *Lonchocarpus* should

[16] Malay. Agr. Jour., vol. 17, p. 326, 1929, and vol. 17, p. 361, 1929.

[17] The difference in rotenone values in sample 743 is perhaps too small to be of much significance.

be made by those in a position to obtain such material. The stem parts of both derris and cube should be investigated for their rotenone content as it is possible that these materials may contain sufficient rotenone to justify harvesting the whole plant rather than only the roots.

CONCLUSIONS

1. The rotenone content of 45 samples of derris root tested ranged from none to about 7 per cent, while that of 23 samples of cube root ranged from less than one to about 11 per cent. The average of the 31 samples of derris root analyzed by the carbon tetrachloride method was 2.5 per cent rotenone, while the average for the 22 samples of cube root analyzed by this method was 5.4 per cent rotenone. These averages should not be considered representative of derris and cube samples in general.
2. These results indicate the desirability of cube root as a source of rotenone. More extensive cultivation of this material is indicated. By selection of high rotenone strains of derris, the rotenone content of this plant could, no doubt, be improved.
3. A close correlation exists between the rotenone content and the total extractive materials of cube root. There is little or no correlation between these two values in the case of the derris root samples.
4. Fine derris roots have a slightly higher rotenone content than coarse roots.
5. Brazilian timbo root may afford an additional source of rotenone.

PALEONTOLOGY.—*Unique coloration of two Mississippian brachiopods.* R. R. Rowley, Louisiana, Mo., and James S. Williams, U. S. Geol. Survey. (Communicated by John B. Reeside Jr.)

New and striking types of color patterns on fossils are always interesting and worthy of record, even though their origin may not be fully understood. Such a pattern has recently been discovered on two specimens of *Acanthospirina aciculifera* (Rowley) Schuchert and Le-Vene, and because it is apparently unique and may possibly be original, and because, even if not original, it may serve to focus critical attention on other color patterns that have been described as original, it seems advisable to call attention to it.

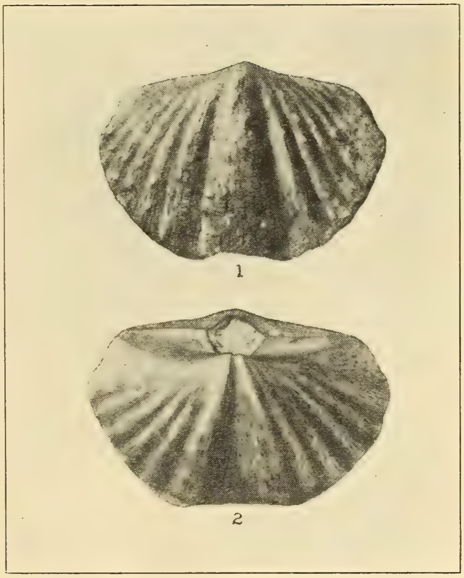
The color-marked specimens were collected by R. R. Rowley from the yellow-brown shale at the base of the Louisiana limestone (Lower

Mississippian), at the mouth of Buffalo Creek, one mile south of Louisiana, Missouri. Their preservation in shale permitted collection without mechanical injury, and thereby favored the retention of the finest markings.

The writers are very grateful to Dr. G. H. Girty and other members of the U. S. Geological Survey for helpful suggestions in the preparation of this notice. Thanks are also due Drs. Aug. F. Foerste and G. A. Cooper of the U. S. National Museum. Doctor Foerste examined the specimens and made suggestions regarding their interpretation and Doctor Cooper gave information about some of the brachiopods cited.

THE COLOR PATTERN

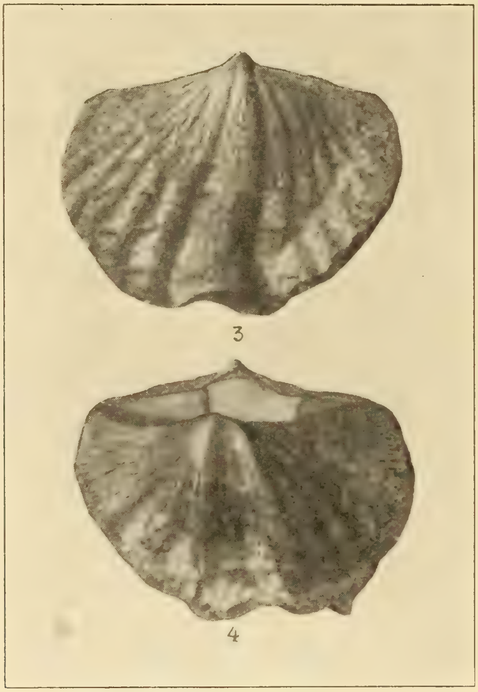
The striking appearance of the color pattern is caused by the bright red color of the markings and their distinctive arrangement.



Figs. 1 and 2. Two views of a specimen of *Acanthospirina aciculifera* (Rowley) Schuchert and LeVene (×8). Fig. 1—Brachial view showing tubercles and colored streaks. Fig. 2—Pedicle view, showing color pattern, which on the specimen is red. Few tubercles are preserved. (R. R. Rowley collection.)

Where most conspicuous the markings consist of bright red streaks and spots which are elongate in directions radial to the beaks and parallel to the plications. Though somewhat irregularly distributed, most of the markings conform to an arrangement in alternating radial

rows. They are about as abundant on the plications as on the intervening furrows and occur both on the folds and in the sinuses. On one specimen the markings are not as abundant in the umbonal region as near the anterior margin, but on the other they are as common over the umbo as farther forward; on one they are more abundant on the



Figs. 3 and 4. Two views of a distorted specimen of *Acanthospirina aciculifera* (Rowley) Schuchert and LeVene (×8), showing color pattern. Note raised position of streaks near cardinal extremities on right side (to left in figure) of specimen shown in Fig. 4. (Univ. of Mo. collection, 5200).

left than on the right, but on the other shell they are about evenly divided between the two sides of the valves. The markings are shown in the photographs, Figures 1 to 4.

The streaks average about 0.16 mm. in length and about 0.02 mm. in width, but a few are longer than 0.16 mm. and others are only slightly longer than wide, being better termed spots than streaks. The markings are separated laterally by spaces that average about 0.1 mm. Examination under a magnification of 25 to 30 diameters, shows that most of the coloring material lies in short discontinuous grooves below the surface but some extends above it forming ridges.

Toward the anterior ends of a few of the grooves the coloring material rises and seems to continue beyond the grooves as short spines. Although most of the coloring material lies below the shell surface and therefore penetrates some of the inner shell layers, an examination under dark field illumination shows that none of it penetrates the innermost layer. Over most of the shell the color of the markings ranges from light brownish-red to dark red, the deeper shade being at the cardinal extremities of one specimen.

The red color of the pigment is probably due to the presence of iron in one or more compounds in the shell substance. Dr. C. S. Ross, of the United States Geological Survey, made a microscopic examination of the most abundant mineral in the red streaks and concluded that it was probably hematite, though the material was too fine grained to permit definite identification. He also found a few larger grains of limonite. Some of the coloring material appeared to him to have been recrystallized in place, and the small particles, he noted, were intermingled with particles of shelly material or imbedded as discrete particles in the shell substance. It was impossible to obtain enough coloring material for reliable and representative chemical analysis, but a few grains of it were tested in the Chemical Laboratory of the U. S. Geological Survey. These tests showed that the grains consisted of somewhat hydrated ferric oxide and that no organic matter was present.

Only four specimens of *Acanthospirina aciculifera* (Rowley) Schuchert and Le Vene are known to the writers. The two described here show the pattern in color, a third has the pattern excavated in the shell surface but not shown in color, and the fourth specimen has not been examined carefully for the pattern. A similar pattern was seen on young specimens of *Syringothyris hannibalensis* (Swallow) Hall and Clarke from the same locality and horizon but the writers have not seen it on mature forms. Other associated shells have incrustations of red material similar in color and composition to that forming the color pattern, but none of them have distinct patterns.

ORIGIN OF THE COLORATION

Rarely is it possible to establish definitely the origin of color markings on fossils. An examination of the literature shows that most of the markings known have nevertheless been described as original. Their origin appears to have been so interpreted because they were arranged in definite patterns which were observed on more than one

individual. Although most of the markings so interpreted probably are original, their regular arrangement and occurrence on more than one individual is not, as will be shown later, of itself, sufficient evidence to definitely prove this conclusion. Satisfactory proof that the coloration on fossils is original is, however, possible. Such an origin can be proved where the chemical composition of the coloring material on the fossils corresponds to that of the pigments on recent shells, but, probably in most part because of changes during and after fossilization, the composition of color markings on most Paleozoic fossils differs from that of the markings on recent forms. Original coloration can be amply demonstrated where the color pattern is the same as a pattern on existing species of the same genus, but unfortunately this is also rare. Most other relations and characters that have been given as proof of original coloration are susceptible also of other interpretations, as a consideration of the Louisiana limestone specimens will show. It is not ordinarily so difficult to demonstrate the origin of secondary color markings, but few examples of them have been described, and the origin of even some of these examples is doubtful.

Like that of many of the markings described in the literature, the origin of the color markings on the Louisiana limestone specimens can not be definitely determined with the data available. Certain hypotheses are, however, favored by these data. A brief discussion of them will bring out interpretations and relations that have heretofore been passed over in studies of this kind and therefore seems desirable. Of these favored hypotheses, three appear to be the most plausible. In two of them, the first and third, the excavated pattern is assumed to have been caused by the coloring material or by material from which it was derived; in the other hypothesis the pattern is assumed to be the result of structural differences which probably did not originally involve differences in color or in shell composition. The three hypotheses are: (1) The coloration is original but has been partly or wholly changed in composition and partly obliterated, (2) the coloration is the result of infiltration of some mineral into openings in the shell, as into the punctae of a punctate shell or into the larger openings of hollow spines, and (3) the coloration is due to differentiation in shell composition (other than that caused by original color differences) which has been exaggerated and brought out by processes of fossilization.

So much is known of the composition of the brachiopod shell, that, unless the original substance of the shell has been replaced—which

seems unlikely in the specimens in hand—the last hypothesis can be dismissed without detailed consideration. Differences in the composition of individual brachiopod shells, aside from those caused by differential and original coloration, largely consist of differences between shell layers. The pattern here described involves differences within shell layers and the arrangement of the materials causing them in a definite pattern. No arrangement of uncolored or uniformly colored materials in any way similar to the pattern has come to the writers' notice and none appears to have been described either from fossil or recent brachiopods. The probable absence of such an arrangement would, it seems, give ample justification for immediately dismissing the hypothesis that depends upon it.

Each of the other hypotheses provides explanations for all the observed characters and relations. The second hypothesis derives its strongest support from evidence furnished by the associated specimens, a source of evidence that has often been neglected. The commonness on associated specimens of stringers and incrustations of red iron-bearing material similar in appearance and composition to the material in the markings can possibly be explained as a fortuitous circumstance, but it shows that there was a plentiful supply of coloring material available for secondary introduction into a structural pattern. Uncolored structural patterns on associated individuals of the same species and on young individuals of *Syringothyris hannibalensis* (Swallow) Hall and Clarke may be interpreted as resulting from the removal of coloring material from original color patterns, but they may also be interpreted as structural patterns that were not originally related to coloration.

The depth of the excavations in which the markings on the color-marked individuals themselves are situated and the irregularity of the markings also favor the hypothesis that a structural pattern was infiltrated with coloring material after the death of the individuals that are now color-marked. The excavations are deeper than the irregularities that usually result from differential weathering of recent shells that have original color markings. The coloring material in five recent shells studied by the writers was in such minute quantities or was so nearly equal to the shelly material in resistance to solution that differential weathering did not affect the shell surface to any extent. This same relation appears to be true for most recent shells and unless the quantity of coloring material in fossil shells were greater than that contained in most recent shells known to the writers, it is doubtful that its removal alone would cause such deep

depressions in the shell substance. Surface irregularities attributed (1, p. 81; 2, p. 212; 3, p. 281) to unequal weathering of pigmented and unpigmented parts of original color patterns on fossil cephalopods and on other fossils are, however, comparable to those caused by the excavations. The slight irregularity of the markings on the color-marked individuals of *Acanthospirina aciculifera* (Rowley) Schuchert and LeVene is not due to any irregularity in the pattern but instead is due to the absence of coloring material from the excavations. This absence might be explained by the assumption that the coloration was original and that unequal weathering of different parts of the shell and of its colored and uncolored parts removed the coloring material from some areas and left it in others; but the irregular distribution over the shell surface of excavations without coloring matter indicates that the absence of coloring matter from them was not the result of greater exposure of some parts of the shells to weathering and suggests that the explanation in terms of the second hypothesis that the irregularities are the result of unequal infiltration is more reasonable. If the coloring material did infiltrate previously formed openings in the shell there would be no reason to expect that it would infiltrate all openings alike or to the same degree.

A distinct obstacle to the acceptance of this second hypothesis is the fact that a suitable structural pattern, known to be unrelated to differences in original shell composition and yet to have been produced by structures known on brachiopod shells, has not been found on specimens of *Acanthospirina aciculifera* (Rowley) Schuchert and LeVene or on closely related forms. Small hollow oblique spines that did not penetrate the innermost shell layer and were arranged in a manner similar to the arrangement of the markings, or very oblique ectopunctae which penetrated some of the inner shell layers and were arranged in a like manner, would provide a satisfactory pattern. Punctae described from very closely related genera are, however, endopunctae and hence penetrate the innermost shell layer as well as other inner layers. Furthermore, they are more or less normal to the shell surface. They would therefore not provide a suitable structural pattern. Some spiriferoid genera have been said to have ectopunctae but they probably do not penetrate inner shell layers (4, p. 420). Other spiriferoid genera have oblique spines which might possibly form excavations if partly removed by weathering or abrasion. If these spines were oblique enough, had their proximal ends buried in the shell substance for some distance, and were arranged in alternate radial rows, they would provide a suitable pattern. No such spines,

however, are known on *Acanthospirina* and because spines of larger size and of a different character are known, it is unlikely that they will be found. Besides being relatively large, the spines on *Acanthospirina aciculifera* (Rowley) Schuchert and LeVene are mounted on tubercles and set at right angles to the shell surface. Broken ends of these spines are irregularly distributed over the surface of the color-marked specimens, but they should not be confused with fine, hollow, regularly arranged oblique spines which would be necessary to form a pattern like that here described. The apparent absence of such a pattern can reasonably be interpreted as favoring the hypothesis that the coloration is original.

The strongest support for the first hypothesis, that the coloration is original, comes from the occurrence together, and in combination, of so many relations that have been observed on recent color-marked forms, or have been described from fossils that have markings rather generally thought to be original. Agreement with most recent color markings is shown in the following particulars: (1) The markings are arranged in a definite pattern which occurs on more than one individual. The comparison is here made with recent forms having definite markings and not with those recent forms that are merely shaded. (2) The markings or excavations, which under this hypothesis are assumed to result from them, occur on all parts of the surfaces of the valves like they do on most recent color-marked shells, and hence are not accidental. Some recent marine shells have markings only on the side nearest the surface, but even on these individuals the markings are regularly distributed on that side. The markings on the writers' specimens appear to be unrelated to life habits. (3) Although the pattern caused by the arrangement of the markings does not closely resemble any color pattern known on recent brachiopods, it does resemble a color pattern that occurs on living gastropods. Such a pattern was seen by the junior author on two immature individuals of a gastropod collected by him on the beach near Beaufort, N. C., and identified by Dr. W. P. Woodring, of the U. S. Geological Survey, as *Crepidula fornicata* (Linné). The pattern on the gastropods consisted of red streaks which were relatively much larger than the markings on the fossil brachiopods. The shortest streaks, which were near the margins of the gastropod shells, formed that part of the pattern which was most like the one here described. (4) Most of the coloring material is in grooves beneath the shell surface, which suggests that, like the coloring material in recent shells, it was situated in the inner shell layers. (3, p. 281; 5, p. 145.) (5) The coloring material appears to be

absent from the innermost shell layers, likewise as in most recent shells. (5, p. 145.) (6) The present color of the markings is perhaps not significant, but it is, nevertheless, a color that is commonly seen on recent color-marked shells. (7) Although the chemical composition of the material does not correspond exactly with that of organic pigments, the presence of iron in it and the discovery (6, p. 92) that iron occurs in pigments of recent molluscan shells may have some significance. (8) Similarity of the markings to recent color markings is also shown by the observation of Doctor Ross that the microscopic particles of coloring matter in the markings of the Louisiana limestone specimens are intermingled with shelly particles, or embedded as discrete particles in the shell substance—a relation noted in recent shells by the writers.

Agreement with markings thought to be original on fossil brachiopods is shown in some details of the color and composition of the markings, in the relation of coloring matter to shell substance, and, in a more general way, in the plan of the pattern. Although the pattern is not exactly like any original pattern on fossils, its radial plan and broad resemblance to them is suggestive. The color patterns on most fossil brachiopod shells consist of bands, long radial lines, or rather large splotches of color whereas the pattern here described consists of short streaks and spots of color of very small size. These differences in size and in the continuity of the streaks are, however, less important than the likenesses shown by its general plan. The coloring matter in most fossil shells occurs in the inner shell layer, as noted by Richter (6, p. 89), Foerste (5, p. 145), and others, and the location of most of the coloring matter in grooves beneath the shell surface on the specimens of *Acanthospirina aciculifera* (Rowley) Schuchert and LeVene suggests that it also occurs in an inner shell layer. Furthermore, its absence from the innermost layer suggests another similarity in position to described fossil markings. The raised position of some of the markings and absence of coloring material from some parts of the pattern are also common features that have been explained by differential weathering of fossil color patterns (2, p. 212; 3, p. 281; 5, p. 145). The color of the markings, though perhaps of a slightly different shade from that of most fossil markings, is nevertheless a rather common one. The colors most commonly recorded on fossil specimens are brown or black, but reddish-brown and purple markings are not uncommon. Reddish-brown, olive-brown, and purplish spots were observed by C. L. and M. A. Fenton (7, pp. 132–133) on two species of *Cranaena* from Devonian of Iowa; reddish-brown spots occur on indi-

viduals of *Pugnax pugnus* (Martin) Hall and Clarke (8, p. 257), and reddish-brown to black concentric lines occur on *Rensselandia cimex* (Richter) Schuchert and LeVene (6, p. 88). The composition of the markings on the Louisiana limestone specimens could not be determined satisfactorily, nor is it known for many markings on fossils, but the presence of iron in the markings suggests a similarity with the composition of other fossil markings. Iron was discovered in the coloring materials of patterns in fossil shells as early as 1871 by Kayser (8, p. 260), who analyzed the substance in the reddish-brown areas of *Pugnax pugnus* (Martin) Hall and Clarke. Richter (6, p. 92) later found traces of iron in colored areas of *Rensselandia cimex* (Richter) Schuchert and LeVene, a Devonian brachiopod, and it has been found in the coloring material of other fossils (1, p. 84; 9, p. 391).

Despite the fact that the agreement in so many particulars of the markings with recent markings or with the criteria used to establish color markings in fossils appears to make the hypothesis of original coloration the most plausible one, it must be conceded that this agreement does not furnish conclusive evidence because the criteria used are themselves inconclusive. Each character and relation of the markings can be explained as a product of secondary infiltration about as well as it can be explained as a product of original coloration. The regularity of the pattern, its occurrence on more than one individual, and its distribution over all parts of the surfaces of each individual can be explained by the second hypothesis by assuming that the pattern existed during life as a structural pattern devoid of coloration. The location of the coloring matter in grooves beneath the shell surface, and its absence from the innermost shell layer, might be attributed to its infiltration into oblique spines or punctae which penetrated some of the shell layers, but did not penetrate the innermost layer, or to the filling of endopunctae which may have penetrated all the inner shell layers. These endopunctae could have been exposed at the shell surface after death by weathering of the outer shell layer and they could have then been partly plugged up before the coloring material was introduced. The raised position and extension of the ends of a few of the markings above the shell surface could also be explained by the hypothesis of secondary infiltration by assuming that the pigment filled hollow spines, or that the shell weathered away more rapidly than the filled punctae. Likenesses in color and—to a certain degree—in composition might be accidental and not particularly significant because red iron-bearing compounds of secondary origin are common on the associated specimens. Furthermore, the

value of the close commingling of particles of shelly material and of coloring material as evidence for original coloration is questionable, for it is true that red iron oxides of secondary origin are known to occur in exactly the same manner.

A careful consideration of the points brought out in the above discussion demonstrates at least to the writers' satisfaction that no choice between hypothesis one and two can be confidently made. From an examination of the literature one would conclude that a pattern like this would ordinarily be described as an original coloration, but the hypothesis of original coloration when tested critically is little, if any, stronger than the hypothesis of secondary infiltration.

If the hypothesis of original coloration is, however, the correct one, the individuals here described provide the first record of an *Acanthospirina* with color markings that are original and the second record of color markings in the Spiriferidae, and they also furnish a new type of original color pattern. If the coloration is the result of infiltration or replacement these specimens are worthy of record, not only because of their resemblance to color patterns that have been described from fossils as original, but also because of their striking and unique appearance. At all events, they serve to draw attention to the difficulty of determining definitely whether color patterns on Paleozoic fossils are of primary or secondary origin.

NEW RELATIONSHIPS SHOWN BY THE COLORED INDIVIDUALS

Quite aside from their interest as color-marked individuals, these specimens are significant because of the new facts they show that bear on the relations of *Acanthospirina*. The species under consideration was originally described by the senior author of this paper as *Spirifer aciculifera*. Weller later chose it for the type species of his genus *Acanthospira*. Schuchert and LeVene (10, p. 119) discovered that *Acanthospira* was a homonym and proposed the generic name *Acanthospirina* to replace it. The essential generic character cited by Weller is the presence of fine spines on the surface, which, he stated (4, p. 418), were arranged in regularly radiating series along the summits of the plications and in similar rows on the fold and sinus. This distinctive character of *Acanthospirina* was inferred from the presence of minute tubercles or papillae, which Weller thought "doubtless supported slender spines in the living shell." (4, p. 419) Weller evidently found no such fine spines in place, but it may now be definitely said that they existed, for one result of the writers' study of these speci-

mens was the identification of three such spines which had been broken off from the summits of the tubercles but were still sufficiently close to enable one to see that they were formerly mounted on the tubercles and projected approximately at right angles to the shell surface. The tubercles themselves, however, are easily seen. That they are neither as nearly equal in number on the two valves nor as regularly arranged as Weller's description would indicate is apparent in Figures 1 to 4. One individual has a considerable number of tubercles on the brachial valve and none on the pedicle valve. The other individual has few tubercles and these are widely and irregularly spaced.

In preparing his generic description Weller did not describe the pattern that forms the subject of this paper, though even where not emphasized by coloration it is visible under moderate magnification on all three specimens recently examined by the writers, including the holotype. Weller (4, p. 390) did, however, describe such a pattern, which incidentally was not shown in color, on *Syringothyris hannibalensis* (Swallow) Hall and Clarke from the same horizon and probably from the same locality. The presence of this pattern on *Syringothyris* suggests an affinity of *Acanthospirina* with *Syringothyris.* This affinity is further indicated by the preservation on one specimen of *Acanthospirina* of a delthyrial plate which bears a median ridge similar to those made by the posterior side of the syrinx on *Syringothyris.* Whether or not this specimen, or any of the other three specimens known to the writers, has a syrinx can not be determined except by sectioning, a course which has not been pursued because of the small number of specimens, only two of which belong to the same collection. In view of these resemblances, however, it appears very probable that when further investigation is possible it will be found that *Acanthospirina* resembles young specimens of *Syringothyris* in every character except in the possession of the fine spines mounted on tubercles.

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BOTANY.—Thelebolus lignicola *and the genus* Pleurocolla (*Fungi*).[1]

WILLIAM W. DIEHL, Bureau of Plant Industry. (Communicated by J. A. STEVENSON.)

Under the name of *Thelebolus lignicola,* C. G. Lloyd[2] discussed and illustrated by three excellent photographs a specimen from New York gathered by S. H. Burnham in 1917. The description is, however, considerably at variance with the evidence obtained from a study of the Burnham specimen in the Lloyd Herbarium as No. 28,444, together with comparisons of other specimens, some in a living condition in moist chamber culture. Examinations of living and preserved material explain in part Lloyd's suppositions and reveal the taxonomic relations of the fungus.

The specimens do not show the presence of ascospores as suggested by Lloyd but of numerous acrogenous conidia upon verticillately branched conidiophores (Fig. 1) massed with paraphysis-like sterile hyphae of irregular length in sporodochia of variable form. The sporodochia when moist are mucose to gelatinous but corneous when dry. When young, they are verrucoid-pulvinate. With increase of size they assume various shapes, subpulvinate to irregularly-columnar, sometimes branched, but in general apically globular to pointed. By virtue of a more rapid growth under conditions of suitable moisture and drying, this apical region of the sporodochium is often, but not always, thrust upward as a subspherical, secondary development or proliferation which extruding readily becomes separated, suggesting a peridiole. It was this peridiole-like feature which prompted Lloyd's reference of the fungus to *Thelebolus.*

[1] Received September 5, 1932.

[2] Mycological Notes, no. 51, pp. 737–738, 1917.

This fungus is in substantial agreement with the description of *Dendrodochium compressum* Ell. & Ev.,[3] and specifically identical with an authentic specimen gathered in West Virginia by L. W. Nuttall (det. J. B. Ellis, No. 923).

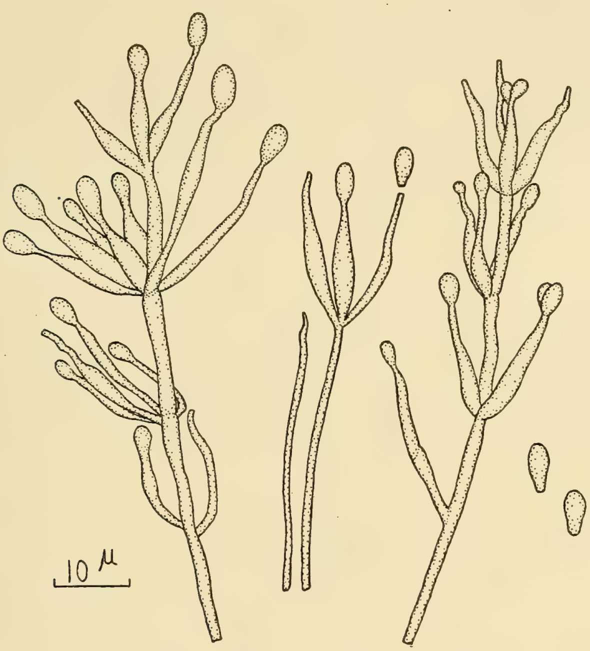

Figure 1. Sterile hyphae and branched conidiophores with acrogenous conidia from the type specimen of *Thelebolus lignicola* Lloyd (= *Pleurocolla compressa*) prepared in Amann's solution. ×1000.

The gelatinous texture of the sporodochium and the verticillately branched conidiophores exclude the species from *Dendrodochium* as typified by Bonorden[4] wherein the conidiophores are not verticillately branched and the sporodochia are not recorded as gelatinous. No published description seems adequate for this type of fructification, but as Miss V. K. Charles suggested to the writer, *Pleurocolla tiliae* Petrak resembles this fungus. Comparisons of the specimens cited below with Petrak's type (Fl. Bohem. Exs. No. 1877) confirmed this suggestion indicating a congeneric relationship. Unfortunately, however, the description of the form genus *Pleurocolla* Petrak[5] does

[3] Bull. Torr. Bot. Club, vol. 24, pp. 475–476, 1897.

[4] Handb. d. Allg. Myk., p. 135, 1851.

[5] Ann. Myc., vol. 22, pp. 15–16, 1924.

not take account of the verticillately compound conidiophores and records the conidia as "akropleurogen" when in reality they are typically acrogenous (Fig. 2). In both species the conidia are borne at the apex of the conidiophores or branches but often remain attached at the nodes after the formation of proliferating conidiophore branches. It is suggested that this type of conidial formation is acrogenous and can not be termed "acropleurogenous."

Both *Pleurocolla tiliae* and *Dendrodochium compressum*, although distinct, are therefore referable to the same genus, but as the technical description of that genus is somewhat at variance with the actual characters observed, it seems desirable to emend the generic diagnosis to include both species as follows:

PLEUROCOLLA Petrak emend.

Diag. Sporodochiis solitariis vel aggregatis, in statura et forme variis, ex cortice erumpentibus vel superficialibus in verrucis usque columnatis irregularibus patefactis, humidis mucoso-gelatinosis, siccis corneis; conidiophoris verticillatim ramulosis; ramis ad apicem attenuatis, tumidulis; conidiis acrogenis, clavatis usque obovatis; hyphis sterilibus, irregularibus conidiophora subaequantibus vel excedentibus.

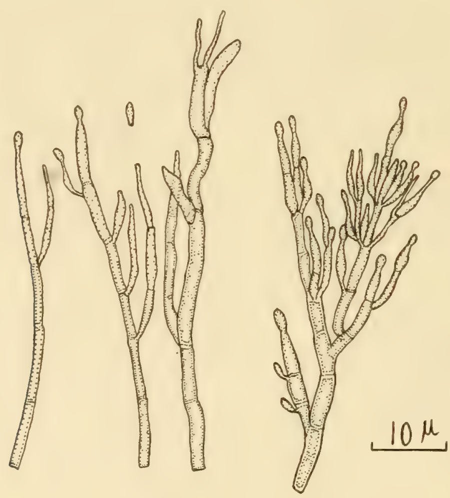

Figure 2. Sterile hyphae and branched conidiophores with acrogenous conidia from the type specimens of *Pleurocolla tiliae* Petrak prepared in Amann's solution. ×1000.

P. tiliae Petrak, Ann. Myc., vol. 22, pp. 15–16, 1924 (type species) Fig. 2.
Specimen examined: on *Tilia platyphylla*, Moravia, 1922, F. Petrak, Flora Bohem. et Morav. exs. No. 1877,—ex-type.[6]

[6] All specimens cited are in the Mycological Collections of the Bureau of Plant Industry.

P. compressa (Ell. & Ev.) n. comb.

Syn. *Dendrodochium compressum* Ell. and Ev. Bull. Torr. Bot. Club, vol. 24, pp. 475–476, 1897.

Thelebolus lignicola Lloyd Myc. Notes no. 51, pp. 737–738, 1917. Fig. 1; Lloyd (l.c.) Figs. 1103–1105.

Specimens examined: Hudson Falls, N. Y., 1917, S. H. Burnham in Herb. C. G. Lloyd 28,444, type of *Thelebolus lignicola;* Cincinnati, O., 1920, C. G. Lloyd in Herb. Lloyd 27,577; Shelbourne, N. H., W. G. Farlow; Chocorua, N. H. 1907, W. G. Farlow; Taughannoc Falls, N. Y., H. H. Whetzel 10,904; Labrador Lake, N. Y., 1932, C. L. Shear; Ross Run, Huntingdon Co., Pa., 1928, L. O. Overholts 11,360; Sligo, Md., 1918, E. K. Cash and V. K. Charles; Arlington Co., Va., 1927, C. L. Shear; on *Liriodendron,* Black Pond, Fairfax Co., Va., 1928, W. W. D.; Dead Run, Fairfax Co., Va., 1929, W. W. D.; on (?) *Liriodendron,* City Point, Va., 1931, W. W. D.; on *Betula lenta,* Fayette Co., W. Va., 1898, L. W. Nuttall (det. J. B. Ellis, 923).

Pleurocolla-like fructifications as stages in the life histories of some discomycetes are to be found in icones of Tulasne and Brefeld. It is noteworthy in this connection that Howarth and Chippendale[7] in a recent paper on the life histories of *Coryne sarcoides* Jacq. and *C. urnalis* Nyl. discuss and illustrate conidial stages that may also be assigned to the genus *Pleurocolla* Syd.

BOTANY.—*Five new oaks from Guatemala.*[1] WILLIAM TRELEASE, University of Illinois. (Communicated by WILLIAM R. MAXON, U. S. National Museum.)

In a recent plant collection from western Guatemala by Dr. Alexander F. Skutch, of Johns Hopkins University, presented to the U. S. National Museum by the collector, there were eight ample specimens of *Quercus,* which were sent to me for study. Three of these I refer to previously known species, as follows: *Q. Donnell-Smithii* Trel., *Q. tristis* Liebm., and *Q. pilicaulis* forma *Hurteri* Trel. The remaining five numbers seem to represent new species, which are described herewith. Duplicate types are in my own herbarium.

Quercus Skutchii Trel., sp. nov.

Ramuli graciles (2 mm. crassi), sulcati, mox glabri, grisei, lenticellis numerosis concoloribus rotundis; gemmae elongato-turbinatae, acutae, 6 mm. longae, 2 mm. latae, brunnescentes, nitidae, squamis pallido-ciliatis; folia sempervirentia, elliptica, 7–8 cm. longa, 3 cm. lata, apice acuta, aristata, basi subacuta, supra glabra, nitida, minute cancellata, subtus tomentosa, venis lateralibus ca. 10, sursum curvatis, supra impressis; petioli 1 cm. longi, glabrati; fructus biennis, brevi-pedunculatus, cupula subturbinata,

[7] Mem. and Proc. Manchester Lit. and Philos. Soc., vol. 75, pp. 47–60, 1931.

[1] Received Oct. 12, 1932.

15–20 mm. diametro, squamis appressis, obtusis, griseo-sericeis; glans elongato-ellipsoidea, 15–20 mm. longa, semi-inclusa.

Type in the U. S. National Herbarium, no. 1,493,800, collected at Chichavac, Dept. of Chimaltenango, Guatemala, alt. 2,400–2,700 meters, Nov.–Dec., 1930, by A. F. Skutch (no. 44).

A large much-branched tree.

Quercus chichavacana Trel., sp. nov.

Ramuli gracilis (2 mm. crassi), parce griseo-pubescentes, lenticellis conspicuis; gemmae rotundo- vel turbinato-ovoideae, argillaceo-coloratae, glabrescentes, plus minusve nitidae, 2 mm. diametro; folia 4–7 cm. longa, 2.5–4 cm. lata, obovata vel elliptico-subobovata, apice acuta vel subacuta, aristata, basi obtusa vel subtruncata, nunc integra, nunc sursum dentata, dentibus setaceis 4–6, supra glabra, nitida, subtiliter cancellata, subtus rufo-tomentosa, venis lateralibus ca. 10, non curvatis; petioli 1 cm. longi, pubescentes; amenta desunt; fructus biennis, brevi-pedunculatus, cupula turbinata, 15 mm. diametro, squamis appressis, plus minusve attenuatis, rufo- vel griseo-sericeis, inflexis; glans ovoidea vel oblonga, semi-inclusa, 1–2 cm. longa.

Type in the U. S. National Herbarium, no. 1,493,803, collected at Chichavac, Dept. of Chimaltenango, Guatemala, alt. 2,400–2,700 meters, Nov.–Dec., 1930, by A. F. Skutch (no. 57).

Quercus chimaltenangana Trel., sp. nov.

Ramuli moderate crassi (4–5 mm.), primum griseo-subtomentosi; gemmae rotundo- vel elongato-ovoideae, obtusae, argillaceo-coloratae vel rufescentes, glabrescentes, subnitidae, 3 mm. diametro; folia 12–14 cm. longa, 4 cm. lata, oblonga vel lanceolata vel oblanceolata, apice acuta, aristata, basi subcordulata, margine crispata, supra glabra nitidaque, subtus tomentosa, ubi denudata granulosa, venis lateralibus ca. 10, apice sursum curvatis, sicut venulis supra impressis; petioli 1 cm. longi, tomentosi; amenta desunt; fructus biennis, brevi-pedunculatus, cupula subturbinata, 15 mm. diametro, squamis obtusis, griseo-sericeis, appressis; glans ovoidea, semi-inclusa, 2 cm. longa.

Type in the U. S. National Herbarium, no. 1,493,805, collected at Chichavac, Dept. of Chimaltenango, Guatemala, alt. 2,400–2,700 meters, Nov.–Dec., 1930, by A. F. Skutch (no. 62).

Quercus ambivenulosa Trel., sp. nov.

Ramuli graciles, 2 mm. crassi, glabri, paulum sulcati, plus minusve rubelli, demum grisei, lenticellis parvis; gemmae rotundo-ovoideae, obtusae, nitidae, pallide fuscae, glabrae, 3 mm. longae lataeque; folia elliptica vel oblonga, 10–14 cm. longa, 3–5 cm. lata, subnitentia, subtus aeneo-colorata, apice basique acuta, glabra, utrinque cancellata, venis lateralibus majoribus ca. 8, falcatis, marginem versus manifeste conjunctis; petioli 10–15 mm. longi; fructus biennis, pedunculis brevibus ramulis crassioribus, fructus 1–3 gerentibus, cupula hemisphaerica, tenui, 15 mm. diametro, squamis arcte appressis, obtuse attenuatis, griseo-sericeis; glans ovoidea, semi-inclusa, 15 mm. longa.

Type in the U. S. National Herbarium, nos. 1,493,798–9, collected at Chichavac, Dept. of Chimaltenango, Guatemala, alt. 2,400–2,700 meters, Nov.–Dec., 1930, by A. F. Skutch (no. 14).

A round-topped tree, 60 feet tall.

Quercus aristigera Trel., sp. nov.

Ramuli moderate crassi, aureo-tomentosi, mox glabrescentes, grisei, internodiis brevibus, lenticellis minutis; gemmae turbinato-ovoideae, griseae, 5 mm. longae, 3 mm. latae; folia decidua, simul cum floribus provenientia, lanceolato-elliptica, 8–11 cm. longa, 3 cm. lata, apice acuta, aristata, basi subtruncata vel cordulata, integra, venis lateralibus ca. 12, vix sursum curvatis; folia junioria supra minute et decidue stellato-puberulenta, subtus pallido- vel aureo-tomentosa; petioli 5–10 mm. longi; amenta 4 cm. longa, floribus congestis, antheris rotundo-ellipsoideis, emarginatis, glabris; fructus biennis, cupula (valde inmatura) obovoidea, truncata, squamis rotundatis, aureis, appressis; stigmata oblonga, recurvata.

Type in the U. S. National Herbarium, no. 1,493,806, collected at Chichavac, Dept. of Chimaltenango, Guatemala, alt. 2,400–2,700 meters, Nov.–Dec., 1930, by A. F. Skutch (no. 86).

BOTANY.—Armouria, *a new genus of malvaceous trees from Haiti.*[1]

F. L. Lewton, U. S. National Museum.

Collections of many interesting plants were made last winter by Dr. David Fairchild and Mr. P. H. Dorsett, with the Allison V. Armour Expedition to the West Indies, in search of new and rare forms worthy of introduction to American horticulture. On January 17, 1932, Mr. Armour's commodious yacht, *Utowana*, touched at Beata, an uninhabited rocky islet off the south coast of Haiti. Here was found growing on a rocky cliff, near the middle of the western coast of the island, a bushy tree, 18 to 20 feet high, bearing large cream-white flowers. Specimens and photographs of the tree, its attractive flowers, and immature fruits were obtained, but no ripe seeds could be found. A return trip was made to Beata on March 22, 1932, when only a few seeds were gathered.

This tree has the aspect of the circumtropical *Thespesia populnea*, but its large cream-white flowers without the darker petal spot present in all species of *Thespesia* and most of its relatives, and the densely pubescent foliage instead of the smooth leathery leaves of *Thespesia*, suggested at once an undescribed species.

Upon study of the herbarium material and photographs brought back by Fairchild and Dorsett, I am convinced that the attractive tree discovered by them represents a new species, which because of the differences of its flowers and fruit from those of *Thespesia* and related genera must be regarded as constituting a new genus.

In recognition of the generous assistance which he has given to botanical research for many years, I have named this genus in honor of Allison V. Armour.

[1] Received December 3, 1932.

Armouria Lewton, gen. nov.

Arbores; folia petiolata, angulato-lobata; flores solitares, axillares; pedunculus sursum incrassatus, angulatus, glandulas tres lineari-cuneatas extraflorales decurrentes et apicem versus bracteas tres deciduas gerens; calyx cupuliformis, sursum truncatus, dentibus quinque minutissimis instructus, deorsum sulcatus et abrupte constrictus, substipitatus, lignescens; columna antherifera apice 5-dentata; ovarium 5-loculare, ovulis in loculis nonnullis; stylus clavatus, stigmatibus quinque decurrentibus; capsula tarde loculicide dehiscens, 5-valvata, lignosa, stellato-pubescens; semina obovoidea, glabra; cotyledones resinoso-punctatae, punctis nigris. Species unica: *Armouria beata* Lewton, sp. nov.

Armouria beata Lewton, sp. nov.

Arbor 5–7 m. alta; ramuli teretes, fuscescentes, minute stellato-lepidoti; folia basi cordata, apice obtusiuscula, 3–5-angulato-lobata, supra scabriuscula, subtus pallidiora molliter stellato-tomentosa; petiolus 1–2 cm. longus; flores ochroleuci, 10–13 cm. lati; pedunculi petiolis 2-plo longiores; bracteae lineari-lanceolatae vel trifidae, 2–3 mm. longae; calyx densissime sed minutissime stellato-puberulentus, dentibus minutis, 0.5 mm. longis; petala basi columnae antheriferae adnata, speciosa, immaculata.

Tree 5–7 meters high; branchlets terete, fuscescent, minutely brownish-stellate-lepidote; primordial leaves cordate-ovate, not angulate; mature leaf blades 3–5-angulate-lobate, 4–6 cm. long and broad, cordate at base, obtusish at apex, scabridulous above, paler and softly stellate-tomentose beneath, palmately veined, the veins (about 7) impressed above, elevated beneath, the midvein provided with a linear nectary midway between base and apex; petioles 1–2 cm. long, about 1.5 mm. thick, stellate-lepidote; flowers solitary and axillary, about 10–13 cm. wide; peduncle twice as long as the petiole, thickened upward, ribbed, provided with 3 linear-cuneate decurrent extra-floral nectaries, surmounted by 3 linear-lanceolate or trifid bracts, these 2–3 mm. long, often unequally inserted, deciduous; calyx cupulate, truncate, with 5 minute teeth (0.5 mm. long), constricted at base into a short sulcate stipe, stellate-puberulent externally, sericeous within, accrescent, becoming woody and verrucose (yet keeping its form), the thickened base then filled with black resinous pellets; petals cream-colored, unspotted, about 6 cm. long; anther column deeply 5-dentate at apex; capsule pointed-ovoid, loculicidal, tardily splitting into 5 woody valves, these densely stellate-pubescent externally; seeds obovoid, glabrous, about 11 mm. long; cotyledons black-resinous-punctate.

Type in the U. S. National Herbarium, no. 1,555,481, collected on a rocky cliff near the middle of the western coast of Beata Island, off the south coast of Haiti, Jan. 17, 1932, by David Fairchild and P. H. Dorsett (no. 2617).

Armouria has as its nearest relatives *Thespesia* and *Montezuma*. From *T. populnea* (L.) Soland., type of the genus *Thespesia*, it differs markedly in its dehiscent fruit and its cupulate, short-stipitate, accrescent calyx, which retains its form to maturity. In contrast, the campanulate calyx of *T. populnea* becomes repand-rotate at maturity. From *M. speciosissima* Moç. & Sessé, type of the genus *Montezuma*, *Armouria* may easily be distinguished by its dehiscent fruit, persistent calyx, and pubescent foliage.

PALEONTOLOGY.—Colognathus *proposed for* Xenognathus, *preoccupied.*[1] E. C. CASE, University of Michigan.

In 1928 the author described (Contributions from the Museum of Paleontology, University of Michigan, Vol. 3, No. 1, pp. 5–6, 1928) an imperfect jaw with two teeth from the upper Triassic beds of western Texas. The jaw was tentatively described as that of a fish and the name *Xenognathus obscurus* was proposed for the new form. It has been pointed out to the author by Doctor H. Walter Clark. of the California Academy of Science that this name is preoccupied and the name *Colognathus* is proposed to replace it.

Further specimens of the teeth and fragmentary jaws have been found in the Palo Duro Canyon and a second specimen has been described by the author (Contributions from the Museum of Paleontology, University of Michigan, Vol. 4, No. 3, p. 90, 1932) but the true character and relationships of the peculiar form remain undetermined.

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

The Carnegie Institution.—The annual exhibition of the Carnegie Institution of Washington was held December ninth to December twelfth. The exhibits were grouped under eleven heads: the growing child, basal metabolism of the monkey, the maternal organism and the egg, the search for an understanding of magnetism, the velocity of light, the sun, climatological research, aboriginal Mexico, seismological research, volcanic gases, and publications.

Three notable lectures by members of the Institution were given during the fortnight immediately preceding the exhibition. The first, on the evening of November 22, was by Dr. E. G. ZIES, on "Volcanic Activity in Central America." Dr. Zies suggested the desirability of a sustained program of volcanological research by an adequately staffed and supported organization, as a means toward the eventual development of a reliable method for predicting eruptions. The extensive volcanic system of Central America, he said, offers as favorable an opportunity for such work as can be found any where in the world.

The second lecture was given by Dr. A. E. DOUGLASS on the evening of December 2; his subject was "Tree Growth and Climatic Cycles." Dr. DOUGLASS demonstrated how the cyclogram method makes it possible to analyze individual cycle series out of the complex that appears in the crude

[1]Received Dec. 14, 1932.

record. He also told of the discovery of the apparent shortening of the main sunspot cycle from eleven years to ten during occasional long "dearth periods" when there are few or no spots on the face of the sun.

In the third lecture, on "Forest Migrations and their Relation to Earth History," which Dr. RALPH W. CHANEY delivered on the evening of December 6, the speaker told of the tracing of Tertiary forest floras on their march from Asia to America, or in the reverse direction, and also of searches in tropical American uplands for forests that still preserve the character they had in higher latitudes in earlier geologic times.

Georgetown University.—White-Gravenor Hall, the newest addition to the Georgetown University group, was dedicated on December 9; it is hoped to have it ready for occupancy by the beginning of the second semester. The top floor will house the Chemistry Department. The equipment and lecture space will be contained in two large classrooms and four laboratories. The attic will accommodate the chemistry reference library, a chemistry faculty room, and an office for the head of the department.

George Washington University Medical School.—Extensive changes and improvements in the physical equipment of the medical school of the George Washington University have been accompanied by a large number of new full-time appointments to the teaching staff. Dean EARL B. MCKINLEY announces the following full-time appointments: ERRETT C. ALBRITTON, M.D., ROSCOE ROY SPENCER, M.D., LELAND W. PARR, Ph.D., JOHN H. HANKS, Ph.D., ELIZABETH VERDER, Ph.D., ALDEN F. ROE, Sc.D., WILLIAM F. HAMILTON, Ph.D., CHESTER E. LEESE, Ph.D., ALICE C. ROBERTS, Ph.D., GEORGE BREWER, M.D., VINCENT DU VIGNUEAD, Ph.D., HELEN M. DYER, A.M., JESSE HARMON, Ph.D., JAMES L. COLLINS, M.D., LANE ALLEN, M.S., PHOEBE J. CRITTENDEN, Ph.D., THOMAS D. WOODSON, M.D.

A new National Aquarium Society.—With the transfer of the aquarium of the Bureau of Fisheries to its new and more commodious quarters in the new Department of Commerce Building and the appointment of a full-time Director of the Aquarium, interest in aquarium fishes, home aquaria, outdoor fish pools, and similar activities has been greatly stimulated. This has culminated in the formation of the National Aquarium Society, the first regular meeting of which was held on November 18, 1932, in the Aquarium in the Department of Commerce, with an attendance of over 100. The object of the Society "shall be the popular and scientific study of the aquarium, its flora, and fauna." The officers are: J. J. FITZPATRICK, president; WM. BROWN, vice-president; ALBERT K. BROWN, secretary-treasurer. The Board of Councilors includes Dr. PAUL BARTSCH, Dr. WM. MANN, FRED G. ORSINGER and Dr. LEWIS RADCLIFFE.

The Pan-American Medical Association.—Under the presidency of Surgeon General H. S. CUMMING, and with an attendance of 25 members, the

Washington Chapter of the Pan-American Medical Association held its first meeting of the season on Friday, November 25, at the Legation of Nicaragua. Certificates of membership were presented to those who had not previously received them. A resolution was unanimously adopted extending the congratulations of the Chapter to one of its most distinguished members, Dr. J. B. SACASA, who has recently been elected President of the Republic of Nicaragua. The scientific program included two formal papers: one by Dr. WM. A. WHITE, Superintendent of the Government Hospital for the Insane, on mental disease, and one by Dr. T. CAJIGAS, on the presumptive Kahn test.

As salient points, Dr. WHITE stressed the extent of mental disease, an expression of the excessive demands of civilization. Taking the present depression as an example of the causes at work, he showed its effects in fewer discharges from institutions, increase of admissions to institutions for defectives, and more suicides. He analyzed the ways in which frustration, with its accompaniments of fear, anxiety, and apprehension works, and its menace to future generations through its striking at the roots of cultural progress. He pointed out as a sign of the times the 200,000 wandering boys throughout the country.

Sigma Xi lecture.—On the evening of November 29, Prof. DOUGLAS WILSON JOHNSON of Columbia gave an address at a meeting of the Society of Sigma Xi at the Carnegie Institution auditorium. Prof. JOHNSON's subject was "Some Research Problems in Earth History." His discussion was largely on certain aspects of geomorphology; it included an explanation of the sculpturing of such mountain systems as the Appalachians by rivers that began to flow as soon as the old drowned peneplain re-emerged from the sea, bearing its load of marine sediments; of lateral planation, strikingly exemplified in desert mountain systems of the West, and of shore erosion by wave action.

Washington Scientists at the A.O.U. Meeting.—At the fiftieth stated meeting of the American Ornithologists' Union, held at Laval University, Quebec, Canada, October 18 to 21, five papers were presented by members of the Bureau of Biological Survey, United States Department of Agriculture, as follows: Dr. O. L. AUSTIN, JR., read two papers, one on "Consistency in Distribution" and one on "The Source of Supply of New England Waterfowl"; ARTHUR H. HOWELL presented "Notes on the Birds of the Coast Region of North and South Carolina"; and F. C. LINCOLN, in a paper illustrated by lantern slides, dealt with "State Distribution of Banded Ducks."

At a special session held in honor of deceased fellows, Dr. H. C. OBERHOLSER delivered a memorial address in appreciation of ROBERT RIDGWAY (1850–1929). Dr. PALMER and Mr. MCATEE were re-elected secretary and treasurer, respectively, of the Union and Dr. OBERHOLSER was renamed a member of the Council.

Dynamic oceanographic and other surveys.—The Hydrographic Office of the Navy Department is undertaking certain important dynamic oceanographic work in connection with its survey season of 1932–1933, which is being conducted by the *U.S.S. Hannibal* and *U.S.S. Nokomis* off Panama and Costa Rica. The primary purpose in obtaining the oceanographic data is to establish correction factors in the areas where it is to be obtained for sonic depth soundings already taken, or to be taken this season, or in the future.

The survey vessels are fitted with sonic sounding devices calibrated to a velocity of 1,463 meters or 4,800 feet a second which register the depths of the waters through which they steam. In depths less than 130 fathoms (780 feet) the depths are automatically recorded, while in greater depths the time elapsed between the start of the signal and the return of the echo from the botton is evaluated by a trained operator.

Unless a determination is made of the specific gravity of the water through which the sound propagated by the sonic sound device travels to the bottom of the ocean and its echo returns to the surface, there is no accurate means of knowing just what the speed of the sound may be. To calculate the true echo-distance, it is necessary to know the mean velocity of the sound between the vessel and the bottom. To determine this mean velocity the salinity and temperature of the water as well as the pressure must be obtained.

Velocity of sound may vary from about 1,400 meters (4,590 feet) per second in cold water to 1,620 meters (5,340 feet) per second at the bottom in great deeps of the world.

The *Hannibal* has been fitted with special equipment for obtaining the necessary factors regarding temperature, salinity, and the pressure of the water. By obtaining a series of soundings from two or more positions on the surface the specific gravity of the intervening water may be interpolated and readily supply correction factors for all sonic soundings taken between these positions.

Mapping the contours of the sea bottom by the surveying vessels will be greatly expedited and will be of the accuracy desired. Simultaneous determinations of the depths with actual soundings by wire and the sonic or echo method with the temperature and salinity of the water at all levels, will provide data of great value in giving the proper information for the velocity of sound in sea-water, and serve as a basis for reducing thousands of sonic soundings that have already been taken by U. S. Naval vessels and other ships.

A third mammalian disease vector.—At the meeting here of the Board of Directors of the Gorgas Memorial Institute, Dr. H. C. Clark, director of the Panama laboratories of the Institute, called attention to a new disease vector, remarkable in that it is the third mammal recorded in this rôle. The animal is the vampire bat, and the disease it carries is trypanosomiasis of

horses, a highly fatal equine ailment of northern South America. The carrier of this disease was long sought among insects, and the blood-feeding bat was tested almost as a last resort. Because the vampire bat feeds by lapping up blood flowing from a wound and not, as popularly supposed, by sucking blood, it does not infect horses when it finds them bleeding from wounds caused by other agencies. But when it finds it necessary to start a flow of blood by making an incision with a knife-like upper tooth, the infective organisms are introduced. The only two other mammalian disease vectors so far known are the dog, carrier of rabies, and the rat, which transmits rat-bite fever.

New Oceanographic Expedition.—Explorations of the greatest "deeps" of the Atlantic Ocean are to be conducted by scientists aboard the yacht *Caroline,* owned by ELDRIDGE R. JOHNSON of Philadelphia, which will sail on her first scientific cruise of the new program about Jan. 15. The first objective will be the deep waters about San Juan, and the party expect to be out about two months.

The program of research includes the determination of depths by means of echo-sounding apparatus, obtaining data on temperature and chemical constitution of the sea water, and collecting specimens of the animal life existing in the perpetually-dark depths. Among other apparatus will be traps using lights of various colors and intensities as lures.

Institutions cooperating in the program, by the loan of staff members and of apparatus, include: the Smithsonian Institution, the U. S. Navy, the Carnegie Institution of Washington, the New York Zoological Society, and the Oceanographic Institution of Woods Hole, Mass. Dr. PAUL BARTSCH of the U. S. National Museum will have charge of the program of scientific work.

NEWS BRIEFS

Ground has been broken for the construction of the new astrographic building and also for the dome of the forty-inch Ritchey-Chrétien reflector, at the U. S. Naval Observatory.

Five additional states have been included by the U. S. Department of Agriculture in the white pine blister rust quarantine area. They are Maryland, Virginia, West Virginia, Ohio, and Iowa.

Since the amendment to the U. S. patent statute permitting the patenting of asexually propagated plants went into effect on May 23, 1930, patents have been granted on thirty-nine plant varieties.

Closer supervision over preparations for transoceanic flights will be exercised hereafter by the Aeronautics Branch of the U. S. Department of Commerce, it is announced. This is designed to discourage inexperienced pilots

and inadequately equipped aircraft, and also to insure that proper permission shall be obtained from the countries to, or in which the American airmen intend to fly.

The American Institute of Chemical Engineers held its annual meeting in Washington during the first week in December. A feature of the meeting was a demonstration of the dust-explosion laboratory of the U. S. Department of Agriculture at Arlington Farm.

A peak in Antarctica has been named Mt. Hugh Mitchell by Admiral R. E. Byrd, in recognition of scientific services performed for his polar expeditions by Prof. Hugh C. Mitchell of the department of astronomy at the Catholic University of America. Mt. Hugh Mitchell is a prominent peak situated between Little America and the Edsel Ford Mountains, forming an outstanding landmark in the antarctic terrain.

There is now in preparation the first volume of the Fourth Series of the Army Medical Library's Index Catalogue. This catalogue was begun in 1865, and three series have been completed to date. The catalogue includes the entire medical literature of the world since printing began.

The Forest Service announces successful tests of an autogyro for use in fire prevention work. Because of the low flying speed of this type of aircraft, its ability to land and take off in small clear areas, its power of hovering and of descending into steep-sided canyons and getting out again, it presents advantages that will make it highly useful for missions which cannot be accomplished by airplanes.

A new bombing plane so speedy that even the fastest existing pursuit planes would have difficulty in overtaking it has been worked out for the Army Air Corps. It is an improvement over the light Martin bomber XB-907, unofficially dubbed the "flying fish."

During 1932, data on 37 "world-shaking" earthquakes were gathered and epicenters located by the cooperative arrangement participated in by the U. S. Coast and Geodetic Survey, Science Service, and the Jesuit Seismological Association. These included five very destructive ones in populated regions of Cuba, San Salvador, Mexico, and Greece.

Personal Items

Prof. H. Hyvernat, of the Department of Semitic and Egyptian Languages and Literatures of the Catholic University of America, has completed preliminary steps looking toward the preparation of a *Catalogue Raisonné* of the great collection of Coptic manuscripts purchased by the late J. Pierpont Morgan, and now the property of the University library.

This collection consists of 58 complete, or almost complete, parchment manuscripts, all of them unique, together with some hundred fragments of manuscripts and about 150 papyri.

M. W. Stirling, Chief of the Bureau of American Ethnology, has been elected Fellow of the Royal Geographic Society.

Maj.-Gen. Robert U. Patterson, Surgeon General of the U. S. Army, has been granted the degree of Doctor of Laws by his alma mater, McGill University.

Col. Edward B. Vedder, Medical Corps, U. S. A., has been awarded the Wellcome Medal for his research, "A Study of the Antiscorbutic Vitamin."

Dr. Alexander Wetmore, assistant secretary of the Smithsonian Institution, has been elected Corresponding Member of the Sociedad Ornitologica del Plata of Argentina.

Dr. Henry G. Knight, chief of the Bureau of Chemistry and Soils, U. S. Department of Agriculture, assisted at the opening of the new Naval Stores Experiment Station near Olustee, Fla.

David H. Madsen, supervisor of wild life of the National Park Service, served as chairman at the Nineteenth American Game Conference, held in New York, November 28 to 30.

Prof. J. de Siqueira Coutinho of the department of economics, Catholic University of America, and visiting professor at the University of Berlin since 1925, last summer made an anthropogeographical survey of the peninsula of Jutland, Denmark, and an economic survey of southern Sweden and the island of Gothland.

Earl Hanson of the department of terrestrial magnetism, Carnegie Institution of Washington, has been in South America during the past year, making observations for the study of secular magnetic variations. He has crossed the Andes and after working along the coast of Peru and Ecuador, he is now closing his work in Colombia and expects to return to the United States early in 1933.

P. G. Ledig of the department of terrestrial magnetism, Carnegie Institution of Washington, will carry out a series of magnetic observations at repeat stations in Peru, Chile, Argentina, and Brazil. He will also obtain cosmic-ray determinations in connection with the project of Prof. A. H. Compton of the University of Chicago.

Dr. P. B. Dunbar, assistant chief, food and drug administration, U. S. Department of Agriculture, spoke before the Association of Official Agri-

cultural Chemists in Washington on November 1, on "The Never-Ending Problems of the Regulatory Chemist."

Obituary

Rear Admiral EDWARD E. HAYDEN, U.S.N. retired, died in Baltimore, November 17. Admiral HAYDEN was the originator of the Navy's standard time service.

Dr. WILLIAM JACOB HOLLAND, director emeritus of the Carnegie Institute, Pittsburgh, Pa., and authority upon zoology, paleontology, and museum administration, died on December 13, 1932, at the age of eighty-four. Doctor HOLLAND was a member of the United States Eclipse Expedition to Japan in 1887 and to West Africa in 1889, the founder and first president of the American Association of Museums, and the author of many scientific papers, including five on Lepidoptera published in the Proceedings of the United States National Museum.

W. H. FRY, soil petrographer of the Bureau of Chemistry and Soils, U. S. Department of Agriculture died, December 27.

ANNOUNCEMENTS OF MEETINGS

The Philosophical Society of Washington announces the following programs:

January 14. L. B. TUCKERMAN.—*From material to structure.* (Address of the retiring president.)

January 28. E. O. HULBURT.—*The use of the bubble sextant at sea.*

F. E. FORBUSH.—*Gravity determinations on the "Carnegie."*

February 11. F. NEUMANN.—*The interior of the earth as revealed by seismographical data.*

F. W. SOHN, S. J.—*The seismic receiver.*

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the tenth of each month.

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JOURNAL

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VOL. 23 FEBRUARY 15, 1933 No. 2

PHYSICS.—*Romance or Science?*[1] PAUL R. HEYL, Bureau of Standards.

The text for my discourse this evening is taken from the editorial columns of the New York Times for September 18.

"Your physicist is supposed to be a hard, matter-of-fact measurer who suppresses romantic speculation and talks only of energy, volts, ions and electrons. Confront him with a mystery and he proves to be as human as the rest of us. Consider the cosmic rays. For years Millikan in this country and Kolhoerster, Hess, Regener, and others in Europe have been studying them only to their own mystification and ours. Measuring instruments are dropped into lakes a thousand feet or elevated twenty miles above sea-level. Piccard imperils his life to determine the true nature of the rays. Professor Compton and a devoted band of physicists station themselves at the Equator, in the far north, on mountain-tops, in deep mines to conduct their investigations. And the result? Romance—sheer romance.

Millikan spins a tale of electrons and protons combining in space, and of resultant cosmic rays that proclaim the continuous upbuilding of the universe, contrary to all the laws of thermodynamics. Jeans holds us spellbound with a poem about stars dying in a fierce radiance and bombarding us with cosmic rays in the process. Regener, as practical as the Irish foreman of a railway section gang when it comes to counting ions, looks at his equations as into a crystal and sees the beginning of things—sees primitive stars shedding cosmic rays and suffusing a relativistic universe from which they cannot escape because it is closed and finite. Stimulated by him, others imagine that, just as the bones of a dinosaur tell us something of the life that was on earth a few million years ago, so these fossil cosmic rays reveal the Almighty in the act of fashioning electrons and protons into nebulae, suns, planetary systems and man himself.

For all the instruments and methods invented to test the cosmic rays, the physicist is still the medicine-man from whom he is descended. Electroscopes and ionization chambers and other cosmic-ray measuring instruments seem strangely like wands and totem poles, and Einsteinian equations but incantations that make us believe we know more than we really do. That

[1] Address delivered before a joint meeting of the Washington Academy of Sciences and the Philosophical Society of Washington, December 15, 1932. Received December 15, 1932.

we are actually dealing with something like wish-fulfillments in the cosmic rays is evidenced by the results obtained. Here is Millikan convincing himself that the cosmic rays prove that the universe is self-perpetuating. And Compton, adopting precisely the same methods, reaches the conclusion that the rays are only electrons swerving to the poles because the earth is a great spinning magnet. What are the cosmic rays? There is no positive answer. We simply try to reconcile what the instruments indicate with our hopes and beliefs and imagine we understand the cosmos."

The same issue of the Times contains an editorial note entitled "It is Done with Mathematics" which reads:

"It is a relief to read that Professor Compton is back from studying cosmic rays in the Arctic region with the definite report that Professor Millikan is wrong. The cosmic ray, says Professor Compton, is not a wave, as Millikan thinks, but a particle.

It is a relief to find that when two men in the high realms of science hold opposite views one of them is right and the other is wrong. Hitherto the public has had to get used to the idea that when two great physicists differ radically about something in the universe the answer is that both men are right.

What is the electron, a wave or a particle? It spreads after going through a hole, like a wave. It hits other electrons like a particle. An electron is both a wave and a particle. That would be nonsense by the rules of common sense, but it makes sense in the new sciences. There is a formula for it.

Some people think that the universe is expanding. Some people think that the universe is contracting. They are both right, says science. Professor Eddington can think of its being an expanding universe and a contracting universe simultaneously. Or, rather, he can find a mathematical formula that will describe that startling situation.

In the same manner space is finite and space is infinite. There is a formula.

Obviously it is a delightful world in which you can have the coffee simultaneously hot and iced and out of the same cup, your egg simultaneously hard-boiled and scrambled, and the griddle cakes at the same time round and oblong.

But occasionally it is a relief to find black as the opposite of white and right as the counterpart of wrong."

Speaking to an audience of scientific men, we may pass with brief mention that portion of what I have read which deals with the disagreement of doctors. This is no new thing in science, and whenever it has occurred it has always been a passing phase characteristic of a stage at which our knowledge on a certain point was for the time too incomplete for unanimity of opinion. But beneath this good humored banter there is to be discerned a serious undercurrent to which we may well direct our attention.

The unsettled condition of modern physical theory has become a commonplace among physicists. It now appears that it has sufficiently penetrated the non-scientific world to produce a state of mingled wonder and bewilderment, suggestive of those earlier days when men

began to doubt the authority and infallibility of the Church. Moreover, it is noteworthy that this bewilderment of the editorial mind seems to be caused wholly by the doings and thinkings of physicists, if among these we may include astronomers, for what is astronomy but celestial physics? Chemists, engineers, geologists and biologists seem to call for no special mention. They are taken for granted as steady going fellows, cobblers with eyes not above their lasts, from whom society is in no danger. But physicists, it appears, are of different clay—iconoclasts, crack-brained theorists, ay, even writers of romance! And, if I guess rightly, this attitude of the editorial mind is not without a measure of instinctive sympathy on the part of many scientific men not of the physical persuasion.

Here is something for us physicists to think about. We are distinctly on the defensive on all sides. Why have we excited this suspicion? Why have we not been able to keep to the straight path with our fellows? If we are no longer regarded as safe and sane, is it our own fault, or that of the subject with which we have to deal?

It must be admitted that among the different conventional divisions of science physics occupies indeed a unique position. Ask the chemist the nature of the atoms and molecules with which he deals and of the forces which rule their reactions, and he will refer you to the physicist for an answer. Ask the biologist concerning the processes of the living tissues which he studies, and he will be apt to tell you that they are but complicated chemical reactions; and the psychologist, if his opinion be asked, will likely say that the subject matter of his study is the most complicated kind of physiology. The psychologist leans upon the biologist, the biologist upon the chemist, and the chemist in turn upon the physicist; but between the physicist and Nature there is no intermediary.

It is the task of the physicist to learn what he can about the fundamentals of Nature, matter and energy and their reactions, which as they rise in complexity form the subject for the study successively of the chemist, the physiologist, and the psychologist. Nor does the engineer, the geologist or the astronomer make use of any principles which may be called distinctively his own; all these merely apply the fundamental principles of physics or chemistry on a large scale. The physicist is, in the best sense of the word, a scientific fundamentalist. If therefore there comes about any change in basic scientific concepts it is the physicist in the front line who first feels the shock.

Now it happens that much of the new and strange in modern physical theory is bound up with two very fundamental concepts—matter

and the atom. In particular, it is noteworthy that a large majority of the published physical work for the last twenty years has been directly or indirectly connected with atomic theory. In this connection there comes to mind the exhortation of President John Adams to the chemists of his day:

> "Chymists! pursue your experiments with indefatigable ardour and perseverance. Give us the best possible Bread, Butter and Cheese, Wine, Beer and Cider, Houses, Ships and Steamboats, Gardens, Orchards, Fields, not to mention Clothiers or Cooks. If your investigations lead accidentally to any deep discovery, rejoice and cry "Eureka!" But never institute any experiment with a view or hope of discovering the smallest particles of Matters."

Is it the old story of Eden? Have we physicists eaten of the forbidden fruit of the tree of knowledge, and are we now suffering the consequences? However this may be, we will maintain, despite all accusations to the contrary, that our plight is not to be ascribed to original sin or to total depravity, but that the changes in fundamental concepts that are causing all the stir have been forced upon us as the logical result of approved methods of scientific study. And so compelling have been the reasons for these changes that there seems to be no more turning back possible for us than for our traditional first parents. We are thrust out of Paradise into contact with the bare world of Nature, and whether we like it or not we must somehow adjust ourselves to the new order of things. Concepts as old as human thinking are gone forever. Strange substitutes are replacing them, and until their novelty wears off it is inevitable that science should for the time appear as romance.

Would that it might ever remain so! But this is too much to expect. The thing that has been is that which shall be. Through familiarity we shall in time adjust ourselves to these new concepts as we have done to the telephone and more lately to the radio, once things of wonder, illumined by the halo of romance, but now mere commonplaces of our daily existence, matters of bargain and sale, at times even degenerating into nuisances and provocations to profanity.

The roots of the present revolution (or evolution) may be traced back for two centuries. The student of the history of science can discern during this period a certain trend of thought of which our present plight is but the logical outcome. This trend may be described as a steady drift away from materialism in our physical concepts.

The natural philosophers of the 18th century followed ancient tradition in explaining everything in terms of matter, which was re-

garded as a *sine qua non,* a basic concept without which physical thought would be impossible. Heat, in the 18th century, was a form of matter called caloric, which differed from ordinary matter in being unweighable, and which could be soaked up by ordinary matter like water in a sponge. Light was another imponderable in the form of very minute corpuscles. Electricity and magnetism were held to be manifestations respectively of the electric and magnetic fluids. Added to these was another imponderable called phlogiston, which was supposed to account for the phenomena of combustion. These five imponderables together with ordinary matter formed the stock in trade of 18th century physics.

The physical science of that period was a rather loose and disjointed affair, consisting mainly of uncorrelated facts about these six supposed entities. But within this chaos there was working the leaven of a principle stated by Newton in his "Principia" as the first of four "Rules of Reasoning in Philosophy": "We are to admit no more causes of natural things, than such as are both true and sufficient to explain their appearances. To this purpose the philosophers say, that Nature does nothing in vain, and more is in vain, when less will serve; for Nature is pleas'd with simplicity, and affects not the pomp of superfluous causes."

In this Newton was but repeating a rule of philosophy laid down three centuries earlier by one of the medieval schoolmen, William of Occam: "Essentials are not to be multiplied beyond necessity." This in its Latin form was a famous saying in the Middle Ages, and was known as "Occam's Razor." In modern parlance it would probably be called a pruning knife. In obedience to this principle the 19th century reduced these six essentials to three, and the 20th century went still further.

It is to be noticed that all the fundamental concepts of 18th century physics were regarded as material, whether they were weighable or not. The 19th century retained the concept of ordinary ponderable matter but did away with the imponderables, replacing them by two new concepts, distinctly immaterial in their nature—energy and ether. Light now became a vibration of the ether; heat was regarded, according to circumstances, either as an ethereal vibration like light (radiant heat), or as a mode of motion of the molecules of matter; and according to a text book of the period electrical phenomena were to be explained either as ether stress or ether flow, while magnetism was a matter of ether vortices. Thus at the end of the 19th century matter had been dethroned as sole monarch, but had been given a place as

a member of a triumvirate—matter, energy and ether—to which were entrusted all the affairs of the universe.

It remained only to take the final step, which was done in the twentieth century. Up to this time the application of Occam's razor to scientific philosophy had been universally approved as conducive to economy of thought and general solidification of theory. But when Einstein pointed out that the concept of matter was not an independent necessity, but could be merged with that of energy, the razor began to cut deep enough to hurt.

Einstein's argument was a strong one, for he showed clearly, and without any reference to relativity, that we must either regard matter as a form of energy or else disregard the experimental evidence for light pressure and also abandon Newton's laws of motion. As the latter alternative was more painful than the first, physical theory accepted the new cut of Occam's razor, eliminating the traditional concept of matter.

With the disappearance of matter as a basic entity the fundamentals of physics can best be described as disembodied ghosts masquerading under mathematical formulas.

"Hindsight is better than foresight." We could hardly expect this crash to have been foreseen, yet it is now clear that the concept of matter was doomed from the time that the trend set in against it. The progress of human thought is like that of some mighty glacier, slow but irresistible.

The atom has always been a subject of interest to physicists and many speculations as to its nature have been advanced. When matter was an unquestioned axiom the atom was explained on a material basis. Newton says in his "Opticks":

> "All things considered, it seems probable to me that God in the beginning formed matter in solid, massy, hard, impenetrable, movable particles, of such sizes, figures and with such other properties, and in such proportion in space as most conduced to the end for which he formed them, and that these primitive particles being solids, are incomparably harder than any porous bodies compounded of them; even so very hard as never to wear or break to pieces; no ordinary power being able to divide what God himself made one in the first creation."

With the growth of the concept of the ether there was a parallel tendency to explain atoms as ethereal phenomena. Kelvin suggested that an atom might be a vortex ring in the ether, something like a smoke ring in air. With the merging of matter into energy the difficulty of explaining the nature of the atom increased greatly, yet the interest in the subject has shown no sign of diminution.

Twentieth century experiment indicates that the atom is built up in some way of positive and negative charges of electricity. The present tendency is to regard the atom as electrical in its essence without committing ourselves to any definite hypothesis as to the nature of electricity. This electrical structure has taken several forms. Bohr's "solar system" model of the atom has "had its day and ceased to be." As far as our present ideas are capable of non-mathematical expression, the atom is to be considered as a collection of probabilities that an electric charge will be found here or there at points in a definite space pattern.

Nebulous and hazy as are our present ideas of the atom, it is evident that this condition is but a corollary to the parallel change that has taken place in our concept of matter, for if we have no clear idea of the whole how can we know more about its parts? We have seen that this change has come as the consequence of an attempt to apply the principle of simplicity and economy in thought as laid down by Occam and Newton. We physicists submit therefore that as far as matter and the atom are concerned the present state of physical theory is not our fault, but is the result of attempting to apply to our subject the most approved rule of philosophy.

The second editorial which I have quoted raises a new question. The bewilderment of the editorial mind is caused here by the bizarre results obtained from mathematical formulas. Here again we may disregard the disagreement of doctors and focus attention on the point of basic importance.

We physicists have used mathematics freely since the time of Newton and the results obtained have until lately always been regarded as regular and orthodox. It is only in the twentieth century that our mathematical conclusions have begun to appear fantastic.

The reason for this is not far to seek. There has been introduced into mathematical physics a body of doctrine which while familiar to mathematicians for upwards of a century had never been taken seriously by physicists prior to Einstein. I refer to the geometry of curved space and of space of more than three dimensions.

Perhaps nothing could be more transcendental and inconceivable than this hypergeometry, but mere inconceivability has never bothered mathematicians; nothing but inconsistency can do that. And it is a fact that once we admit the fundamental postulate of a fourth dimension it becomes possible to build up a hypergeometry as logical and consistent as that of Euclid.

The introduction of these novel concepts into physics has not taken

place without a struggle. Much of the opposition disappears, however, when one realizes that Einstein did not propose these hypotheses as physical facts, but merely as a sufficient, though not necessary, mathematical description of certain phenomena. He himself regards this child of his brain quite sanely. "No amount of experimentation," he is reported to have said, "can ever prove me right. A single experiment may at any time prove me wrong." Yet the theory of relativity has gradually gained a hearing and a growing acceptance because of performance, by its ability to do things a little better than was possible before. Though its conclusions often appear strange, some of them have been experimentally verified, and as a result we have added to our stock two new phenomena—the deflection of light rays passing close to the sun and the shift of the Fraunhofer lines in an intense gravitational field. With these practical results to support us, I think we may maintain that hypergeometry and the theory of relativity have justified their provisional acceptance as working tools, no matter how romantic their conclusions. Even the concept of an expanding universe may yet be experimentally verified. Things equally strange have happened.

We may now consider another possible item in the indictment against us, one of which we shall have to accuse ourselves, as it apparently had not yet reached the editorial mind. Physicists themselves have been much concerned over an attack by certain of their own number upon nothing less than the law of cause and effect. It is truly remarkable that such an attack should have come not from the anti-scientific but from the high priests of science themselves.

This latest skepticism concerns itself with the behavior of the electrons. The phenomena exhibited by these minute bodies have always been in some respects puzzling and incalculable, but scientific thought has been steadily optimistic, confidently awaiting the ultimate solution. The essence of the new view is that the behavior of an electron is incalculable, not because the problem is as yet too complicated for us, but because, to state it baldly, the actions of individual electrons are not governed by the ordinary law of cause and effect. The new philosophy recognizes that where an individual electron may be at this moment is a matter of observation, more or less imperfect; it admits that where the electron has been in the past is a matter of history; but it asserts that where it will be in the future is a matter not for definite prediction but only of statistical probability.

This doctrine appears to strike at the root of all law and order, and yet, curiously enough, its protagonists recognize the existence of a

kind of law on the large scale, but deny that it extends to individual units. The new philosophy is not such a complete reversion to primitive type as might be hastily concluded.

Perhaps the best illustration that we can give of this new thought is one based upon the behavior of units large enough to be familiar if not altogether comprehensible—human individuals.

The behavior of any individual under given conditions is, rigidly speaking, unpredictable. For your belief that I will react in a certain way to my environment you have nothing but a probability, perhaps a very high one, amounting to what you may consider practical certainty, but never more than a probability. No one can say with absolute certainty that I will not, let us say, steal money during the coming year. It may be in the highest degree unlikely that I will, so unlikely that you may consider it insulting to harbor any suspicion of me, yet experience shows that occasionally an ordinarily well-behaved man may do a most unexpected thing. While no one can say definitely just what you or I or he or she will do, yet with several millions of such individuals to serve as a basis for prediction it is possible to estimate just how many of them will depart from rectitude during the next year and how much money will be involved in the total sum. Such is the accuracy of this prediction that bonding companies risk their capital on it year after year, and make money. Individually, man is more or less of an enigma; in the mass he is a mathematical problem.

Something very like this is the latest turn of scientific thinking. It asserts that the future behavior of a single electron is incalculable. We can not tell whether it will turn to the left or to the right, whether its velocity will be accelerated or retarded. All that we can say is that there is a certain percentage probability of any particular behavior, and that such a prediction is always verified by the result when a sufficiently large number of electrons is taken into consideration. In the electronic realm there is no individual causal certainty. Instead there is something which in a conscious organism we would call caprice. Dirac even uses the term "the free will of Nature." Yet as we pass from the individual to the crowd certain laws begin to appear, but they are no longer causal laws; they are only laws of probability.

There is a certain measure of experimental support for this position. The evidence is rather involved, and is circumstantial and cumulative rather than direct and specific, but this is not a fatal objection. And there is an imposing array of authority which has accepted this evidence—Bohr, Heisenberg, Dirac, Jordan, Born, Eddington, Bridg-

man, and others. The situation has been well summed up by de Broglie in one of his essays from which I quote the following sentences.

"Causal laws replaced by laws of probability, physical individuals well localized and of well defined movement replaced by physical individualities which refuse to let themselves be simply represented and can never be more than half described: such are the surprising consequences of the new theories. In digging under these laws of probability, shall we succeed in re-finding causal laws as we have found recently behind the statistical laws of gases the causal laws of the movement of molecules? Certain arguments would lead to this belief, but it would be indeed imprudent to assert it.

What we have said suffices, we think, to show the importance of the change in the point of view which has recently taken place in physics. Whatever may be the final fate reserved for these new doctrines it is of infinite interest to philosophers that physicists have been led, even though but for the moment, to doubt the determinism of physical phenomena and to question the possibility of describing them in a complete fashion within the frame of space and time."

Perhaps it would be well now to pause, to catch our breath and see where we stand, if indeed we have anything left to stand on. Well may we echo the dismayed queries of Macbeth and Banquo after the disappearance of the three weird sisters:

"The earth hath bubbles, as the water has,
And these are of them. Whither are they vanish'd?"

"Into the air; and what seem'd corporal melted
As breath into the wind. Would they had stayed!"

"Were such things here as we do speak about
Or have we eaten of the insane root
That takes the reason prisoner?"

I think that we may feel safe as to the answer to the last question. The reassuring thing about all these new and strange theories is that they work. By means of them we are able to cut a little more closely to the line than was possible under the old regime. Practical physics was never more satisfactory; theoretical physics never less so.

This divergence between theory and practice is not to be understood as meaning that practice is being divorced from theory to its own advantage. On the contrary, there never was a time when practice was more closely dependent upon theory than today. New researches are almost invariably suggested by theory, and their results in a reasonable number of cases are confirmative of the theoretical prediction. Never was theory more fruitful. If we were totally on the wrong track, would Nature give us the abundant encouragement that she does? "By their fruits ye shall know them."

The difficulty with modern physical theory is not a lack of consistency; that mathematical requirement it possesses in abundance. It is the elusive and unreal nature of its fundamental concepts that gives us pause. But who are we that we should reproach Nature with being unreal? Perhaps the fault lies in our definition of reality, and of that Nature herself is the final and supreme judge. Guided by her answers to a century of experimental question, we have drifted steadily away from the material toward the immaterial in our fundamental concepts. If as a consequence science assumes an aspect of romance, perhaps this is because for the first time in the history of human thinking we have come close enough to reality to catch a glimpse of it. The picture is very different from that to which tradition has accustomed us, but so thought the contemporaries of Columbus and those of Galileo. And if the more closely we study Nature the more romantic she appears, perhaps we are but rediscovering something which the poets have always known and have not hesitated to utter.

> "And like the baseless fabric of this vision,
> The cloud-capp'd towers, the gorgeous palaces,
> The solemn temples, the great globe itself,
> Yea, all which it inherit, shall dissolve
> And, like this insubstantial pageant faded,
> Leave not a rack behind. We are such stuff
> As dreams are made on, and our little life
> Is rounded with a sleep."

Romance or science—which shall we call it? It matters little once we have been granted the vision to see that the two are not only consistent but inseparable.

MINERALOGY.—*Crystals of iron-rich pyroxene from a slag.*[1] N. L. BOWEN, Geophysical Laboratory, Carnegie Institution of Washington.

INTRODUCTION

In 1928 Dr. A. L. Day received from Mr. Oliver C. Ralston some specimens of a crystallized product formed in a slag during the cooling of a reverberatory furnace of the United Verde Copper Company, Clarkdale, Arizona. In his accompanying letter Mr. Ralston stated his opinion that the crystals would prove to be a high iron pyroxene, which opinion was entirely correct. At the time of their receipt the crystalline masses were turned over to the writer, but, aside from verifying their general character, no detailed study was made of them.

[1] Received October 7, 1932.

Since then a study of the system, CaO-FeO-SiO_2, has been completed[2] and pyroxenes of a like character found to form in mixtures belonging to that system. This fact led to a re-examination of the well crystallized slag material, the results of which seem worthy of record since they extend our knowledge of the crystallographic and optical properties of the pyroxenes to compositions richer in iron than any hitherto observed.

GENERAL CHARACTER OF MATERIAL

The masses consist of interlocking platy crystals of pyroxene from the interstices of which any excess slag that may have been present during their formation has drained away. Into the resulting vug-like spaces protrude euhedral crystals of pyroxene suitable for goniometric and optical measurements.

CRYSTALLOGRAPHY

The crystals are always tabular parallel to *b* (010), invariably show *m* (110) and *o* ($\bar{2}21$), and usually no other forms. On the 8 crystals measured two other forms were observed, *s* ($\bar{1}11$) occurring on two of them and *z* (021) on one of them. Reflection signals from the faces were fair to good. The crystals are:

Monoclinic $a:b:c = 1.0786:1:0.5828$

$\beta = 71°31'$

Observed and calculated interfacial angles are given in Table 1.

TABLE 1

Observed and Calculated Interfacial Angles of Pyroxene Crystals

monoclinic $a:b:c = 1.0786:1:0.5828$

$\beta = 71° 31'$

		Observed	Calculated
$b:m$	(010):(110)	*44° 20′	—
$b:s$	(010):($\bar{1}11$)	*60° 17′	—
$m:s$	($\bar{1}10$):($\bar{1}11$)	*60° 28′	—
$b:o$	(010):($\bar{2}21$)	47° 19′	47° 47′
$m:o$	($\bar{1}10$):($\bar{2}21$)	35° 53′	36° 17′
$m:o$	(110):($\bar{2}21$)	80° 54′	81° 3′
$b:z$	(010):(021)	42° 8′	42° 7′
[*b m*]:[*b o*][a]		51°	51° 1′

[a] Interzonal angle measured on the stage of the microscope.

OPTICAL PROPERTIES

The plane of the optic axes is parallel to 010 and the extinction angle $(c \wedge \gamma) = +36°$. The refractive indices measured in immersion

[2] Bowen, Schairer, and Posnjak (soon to be published).

liquids under the microscope are $\gamma = 1.785$, $\alpha = 1.745 \pm .003$. The optic axial angle is small, $+2V = 20\text{–}25°$. The prismatic cleavage is perfect and the extinction on cleavage plates is 28°. Pleochroism is notable, γ = green, β = amber, α = smoky brown.

CHEMICAL COMPOSITION

The crystals of pyroxene contain abundant opaque inclusions. Some of these are fairly large and recognizable as dodecahedra of magnetite. Others appear as a mere dust which is, in part at least, a sulphide. The larger crystals can be separated, but when this is done the pyroxenic residue with its fine inclusions is still a rather unpromising material for analysis.

It is probable, therefore, that analysis of separated material would add little to the knowledge of the composition of the pyroxene already available in the form of a bulk analysis furnished by Mr. Ralston. The analysis is shown in Table 2.

TABLE 2

Bulk Analysis of Material Selected by Mr. Ralston

	Per cent
Cu	0.2
SiO_2	39.3
Al_2O_3	4.8
FeO[a]	43.4
Zn	3.5
CaO	2.7
MgO	3.3
S	1.1
	98.3

[a] All iron expressed as FeO.

We do not, of course, acquire an accurate knowledge of the composition of the pyroxene from this information but, knowing that there is only one silicate present whose silica ratio must be approximately that of a metasilicate, and that magnetite is the principal impurity, we may recalculate the analysis with the result given in Table 3.

TABLE 3

Recomputed Analysis of Selected Material

	Per cent
$FeSiO_3$	69.3
$CaSiO_3$	6.7
$MgSiO_3$	8.2
Al_2O_3	4.8
Fe_3O_4	5.2
ZnS	3.4

Only a little Zn is thus left unaccounted for. It may enter into the pyroxene to some extent. The Al_2O_3 may be largely in the pyroxene, which may also contain some Fe_2O_3. Recognizing these elements of uncertainty we may yet say that the pyroxene does not depart greatly

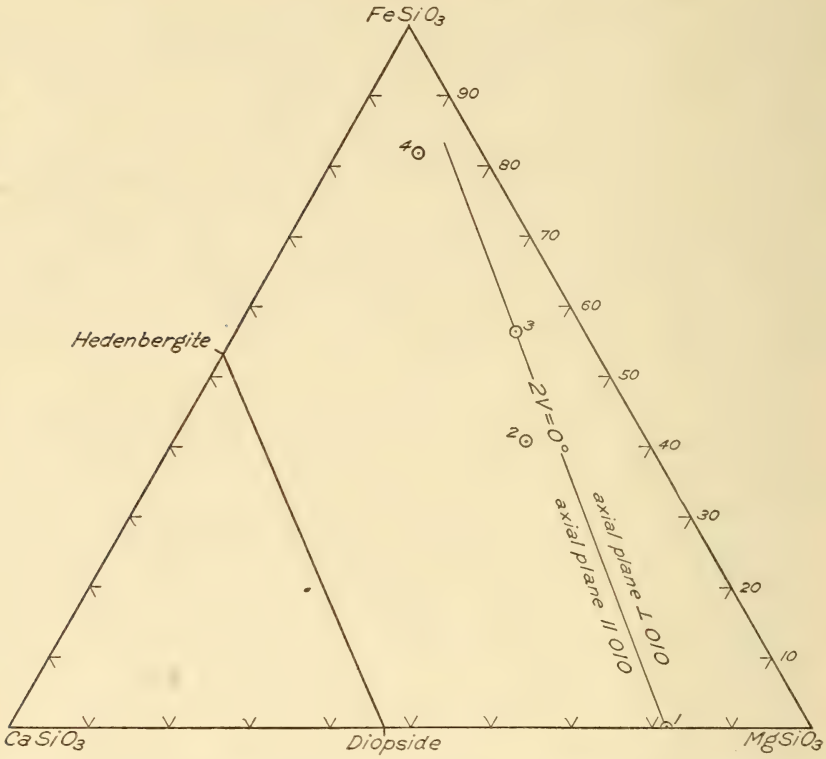


Figure 1.—Plot showing the composition of four pyroxenes of small optic axial angle.

1. Synthetic pyroxene $2V=0°$. $\gamma=1.670$. Bowen, Op. cit., p. 252.
2. Pyroxene from Föglö, Aland Islands $2V=15–20°$. $\gamma=1.711$. Wahl, Op. cit., p. 16.
3. Pyroxene from Mull $2V=0°$. $\gamma=1.744$. Hallimond, A. F., Min. Mag. vol. 17, p. 17, 1914.
4. Present slag pyroxene $2V=20–25°$. $\gamma=1.785$.

from a composition represented by the three metasilicate molecules at the head of the list. These, made up to 100, and rounded off to the nearest integer, give a composition $FeSiO_3$ 82 per cent, $CaSiO_3$ 8 per cent, $MgSiO_3$ 10 per cent. We may thus be sure that the pyroxene carries in the neighborhood of 80 per cent $FeSiO_3$.

The indicated content of $FeSiO_3$ far surpasses that yet found in any natural pyroxene and apparently in any slag pyroxene as well. The

measured high values of the refractive indices are in accord with this fact.

SYSTEMATIC RELATIONS

The pyroxenes of low optic axial angle and their chemical relation to the other pyroxenes have been of considerable interest ever since their discovery by Winchell[3] and the demonstration by Wahl of their widespread occurrence in certain types of rocks.[4] The present example extends our knowledge of them to a composition region hitherto unknown, a fact brought out in Fig. 1, which shows the relation to other pyroxenes of low optic axial angle. A straight line joining the composition of the synthetic pyroxene[5] (No. 1) with the point indicating the Mull pyroxene (No. 3) leaves the points for the other two pyroxenes (Nos. 2 and 4) only a short distance to the left, which is in accord with their very small optic axial angles and the position of the axial plane//010. Pyroxenes with compositions lying to the right of the line have the axial plane ⊥010. The position of the line of zero optic axial angle is necessarily only a first approximation since in plotting all the pyroxenes except No. 1 it has been necessary to neglect minor constituent molecules.

ACKNOWLEDGMENT

Thanks are due Mr. Ralston for sending us this interesting material.

CRYSTALLOGRAPHY.—*Vogtite, isomorphous with wollastonite.*[1]

N. L. BOWEN, Geophysical Laboratory, Carnegie Institution of Washington.

GENERAL CHARACTER OF VOGTITE

Under the name, vogtite, Hlawatsch in 1906 described some triclinic crystals obtained from a slag of unknown origin. Their composition was not determined but they appeared to correspond with crystals of the (Mg, Fe, Mn) SiO_3 series whose existence had been pointed out by Vogt, and to this series they were consequently referred.[2] Hlawatsch's crystals were well developed and he was able to

[3] Winchell, A. N., Amer. Geol., vol. 26, p. 199, 1900.

[4] Wahl, W., Tsch. Min. petr. Mitteil., vol. 26, pp. 1–131, 1907.

[5] Bowen, N. L., Amer. Jour. Sci., vol. 38, pp. 245–254, 1914.

[1] Received October 11, 1932.

[2] Hlawatsch, C., Z. Kryst., vol. 42, p. 590, 1906.

determine their angular constants. He referred them to a system of axial elements as follows:

$$a:b:c = 0.51826:1:1.11588$$

$$\alpha = 93°26'30'', \quad \beta = 103°59'12'', \quad \gamma = 83°50'8''$$

In 1919 Hallimond described similar material from the slag of an acid hearth steel furnace.[3] His crystals were analyzed (by J. H. Whiteley) with the result given in Table 1.

TABLE 1.—ANALYSIS OF HALLIMOND'S VOGTITE

	Slag crystals	mols.
SiO_2	47.4	0.790
Al_2O_3	0.15	
Fe_2O_3	2.7	.257
FeO	15.95	
MnO	12.95	.182
CaO	15.1	.270
MgO	5.26	.131
TiO_2	0.10	
	99.61	

The composition is not far from that of a metasilicate. The general formula may be written (Ca, Fe, Mn, Mg) SiO_3 in which Ca exceeds any one of the constituents in brackets with it but is very much in the minority as compared with the sum of these others.

Hallimond found his crystals to have essentially the same angles as those measured by Hlawatsch and gives a table showing their correspondence. Nevertheless, he chose a different orientation and referred them to the following system of axial elements:

$$a:b:c = 1.093:1:0.729$$

$$\alpha = 99°37', \quad \beta = 99°21', \quad \gamma = 83°53'$$

Hallimond's stereographic projection plot can be brought into coincidence with Hlawatsch's by simple revolution combined with a reversal; in other words, it refers to the opposite end of a crystal. Now if the Hlawatsch-Hallimond projection thus obtained is compared with the projection of wollastonite having its *b* axis in the pole of the projection, a remarkable agreement is found. All of the forms of vogtite show near coincidence with known or possible forms of wollastonite. The correspondence of faces in the ortho-zone of wollastonite with faces of the prism zone of vogtite is practically perfect. Of forms belonging to other zones *e* (Hlawatsch) and *p* (Hallimond) nearly coincide with (142) of wollastonite, *d* (Hlawatsch) with $(14\bar{2})$ of wol-

[3] Hallimond, A. F., Min. Mag., vol. 18, p. 368, 1919.

astonite and l (Hallimond) with ($\bar{3}42$) of wollastonite. The forms (142) and ($\bar{1}42$) of wollastonite have been observed only on crystals from Crestmore, California.[4] The form ($\bar{3}42$) has apparently not been observed on wollastonite.

The general correspondence of forms being thus qualitatively determined with the aid of a projection, the actual degree of correspondence is best shown by comparison of the numerical values of interfacial angles. This is done in Table 2. The angles given for vogtite are those

TABLE 2

RELATION OF FORMS OF VOGTITE TO THOSE OF WOLLASTONITE

Forms			Angles		
Vogtite (Hlawatsch)	Vogtite (Hallimond)	Wollastonite	Vogtite (Hlawatsch)	Vogtite (Hallimond)	Wollastonite
a (100)	m (110)[a]	a (100)[a]	$a:m$ 50° 19′	$m:a$ 50° 10′	$a:t$ 50° 25′
m (110)[a]	a (100)	t ($\bar{1}01$)[a]	$a:M$ 44° 22′	$m:b$ 44° 34′	$a:v$ 44° 27′
t (120)[a]	n ($3\bar{1}0$)	α ($\bar{1}02$)[a]	$m:M$ 94° 41′	$a:b$ 94° 45′	$t:v$ 94° 52′
b (010)[a]	M (110)[a]	c (001)[a]	$a:b$ 95° 30′	$m:M$ 95° 10′	$a:c$ 95° 30′
M ($1\bar{1}0$)[a]	b (010)	v (101)	$a:t$ 69° 51′	$m:n$ 69° 53′	$a:\alpha$ 69° 56′
d (011)	—	ϵ ($\bar{1}42$)	$a:d$ 80° 10′	—	$a:\epsilon$ 80° 29′
e ($0\bar{1}1$)	p' ($01\bar{1}$)	ω (142)	$b:d$ 64° 47′	—	$c:\epsilon$ 64° 15′
—	—	—	$a:e$ 75° 26′	$m:p'$ 75° 30′	$a:\omega$ 75° 38′
—	—	—	$b:e$ 61° 34′	—	$c:\omega$ 62° 11′
—	l (101)	— ($\bar{3}42$)	—	$m:l$ 59° 39′	$a:\bar{3}42$ 58° 36′
—	—	—	—	$a:l$ 50° 41′	$t:\bar{3}42$ 50° 40′

[a] Cleavage forms. m (Hlawatsch) doubtful.

found by Hlawatsch and by Hallimond. Wollastonite angles are, for the most part, taken directly from tables of interfacial angles in Dana's System. Those referring to the recently discovered wollastonite forms (142) and ($\bar{1}42$) are calculated from their ϕ and ρ values as given by Eakle. Those referring to the undiscovered wollastonite form ($\bar{3}42$) are calculated from the axial elements as given in Dana.

Little comment upon the table is necessary. It may be noted, however, that of the four cleavages of wollastonite, all in one zone, the two best were found in vogtite by Hallimond, and three of the cleavages found by Hlawatsch correspond with three of wollastonite, but the fourth Hlawatsch cleavage, although in the same zone, does not appear to correspond with the fourth wollastonite cleavage, which is the very best. It is possible that in his thin-tabular crystals the existence of a cleavage parallel to the tabular face may have been overlooked. However this may be, the remarkable agreement of vogtite with wollastonite cannot be gainsaid.

[4] Eakle, A. S., Bull. Dept. Geol. Univ. California, vol. 10, pp. 336–338, 1917.

ORIENTATION OF VOGTITE

All of this suggests that vogtite might be referred to a set of axial elements nearly identical with those conventionally assigned to wollastonite and be regarded as monoclinic. But vogtite is definitely triclinic as shown by the relation of the optical indicatrix to crystallographic directions. Moreover, wollastonite, hitherto regarded as monoclinic, has been shown by recent X-ray investigation to be of triclinic structure.

The study is by Warren and Biscoe, who say:

> "Altho wollastonite and pectolite are definitely triclinic they have a most unusual and pronounced pseudo-monoclinic symmetry. The angle γ is such that the 410 direction, which has always been taken as the direction of the 'a' axis, seems to make exactly 90° with the 'b' axis. What is even more striking is the fact that on the complete set of 'b' axis oscillation photographs all the spots on the even layer lines show perfect monoclinic symmetry, both as regards position and intensity of spots. This means that altho wollastonite and pectolite are triclinic, if the lattice were translated by an amount $b/2$ and superimposed upon itself the resulting configuration would have true monoclinic symmetry."[5]

The unit cell has dimensions which yield the axial elements:

$$a:b:c = 1.083:1:0.967$$
$$\alpha = 90°, \quad \beta = 95°16', \quad \gamma = 103°25'$$

In view of the near identity of the interfacial angles of vogtite and wollastonite the axial elements for vogtite will obviously be nearly the same, and it is somewhat superfluous to calculate them. Nevertheless, this has been done, with the following result:

$$a:b:c = 1.076:1:0.9643$$
$$\alpha = 90°43', \quad \beta = 95°10', \quad \gamma = 103°35'$$

In considering the position of the observed vogtite faces in this structure it is of interest to note the relation between the new and the old ratios for wollastonite. The commonly accepted constants referring it to monoclinic symmetry are

$$a:b:c = 1.0531:1:0.9676, \quad \beta = 84°30' \ (95°30')$$

In the new constants (already given) it will be seen that there is no change in the relative lengths of the b and c axes or in their rectangular relation to each other. The only change is in the a axis which is no longer perpendicular to b and is lengthened in accordance with its inclination of 13°25′ from that position. In virtue of this change the face with the symbol 140 referred to the old axes now becomes the pinacoid b 010. Likewise the observed vogtite faces, referred to the fundamental structure (new wollastonite axes), have their symbols

[5] Warren, B. E., and Biscoe, J., Z. Krist., vol. 80, p. 401, 1931.

notably simplified as compared with their symbols referred to the old wollastonite axes. The vogtite face which was found to correspond with 142 of wollastonite (old axes) now becomes 021, that corresponding with $14\bar{2}$ (old) of wollastonite becomes $02\bar{1}$ and that having the position of the unobserved $\bar{3}42$ (old) face of wollastonite becomes $\bar{2}21$.

FACE DEVELOPMENT IN WOLLASTONITE

The clinopinacoid 010 (old) has been observed only doubtfully on one occasion in wollastonite crystals. This fact, in itself, rather suggests a lack of agreement of the crystal lattice with the conventional axes, but the same reasoning would lead one to expect that the 140 (old) face should be very common since it is structurally the pinacoid 010 (new axes). In point of fact it was not until the measurement of crystals from Crestmore, California in 1917 that faces of that form were discovered. On these it is the most prominent "prism." The crystals are unusual in other respects. They exhibit no prisms bearing a simple relation to the conventional wollastonite axes, but do show the series 140, 340, 540, 740, and Eakle comments on the odd series of symbols. When these forms are referred to the new axes the symbols are transformed as follows, each monoclinic prism giving rise, of course, to two triclinic forms, $140 = 010$, $\bar{1}40 = \bar{1}20$, $340 = 120$, $\bar{3}40 = \bar{1}10$, $540 = 110$, $\bar{5}40 = \bar{3}20$, $740 = 320$, $\bar{7}40 = \bar{2}10$. The simplification of indices which results indicates a preference for the new axes on purely crystallographic grounds. In addition the Crestmore crystals are triclinic in aspect. On this point Eakle says: "Only one end of the crystals is terminated, sometimes the right and again the left end. The disposition of the faces indicates a lower grade of symmetry as there is no apparent axis of symmetry and the crystals could belong to the hemimorphic class of the monoclinic system, or to the triclinic system." But when all of this has been said it still is to be remembered that the Crestmore crystals are exceptional, and the remarkable fact remains that crystals of wollastonite, as described from other localities, have always furnished adequate justification for referring them to the monoclinic system and to the accepted system of axes. Prisms having simple indices referred to these axes are very common in wollastonite. In this respect the related pectolite is more straightforward. It shows the prisms 140, 340, 540, and none other. They have, as noted above, much simpler indices referred to the new axes.

POSITION OF THE OPTICAL INDICATRIX

Another remarkable feature of wollastonite is the fact that the *b* axis, which has always appeared to be an axis of symmetry, should

also appear to coincide with an axis of the optical ellipsoid. Ordinarily this is a very satisfactory test of monoclinic symmetry, for, even in a case where the angular departure of faces from such symmetry is too small to detect, there is little reason to expect that the departure of the optical ellipsoid from parallelism would also be very small. In order to check previous observations on wollastonite some Crestmore crystals[6] were examined for parallelism of the extinction direction, with the *b* axis, i.e., the zone of cleavages. The results appear to indicate a slight extinction angle (1.5–2°) in the section which shows normal emergence of the acute bisectrix. The inclination of the extinction direction is not readily observed in this section in the ordinary manner in parallel light. The optic axial angle of wollastonite is so small that the position of extinction is not sharply defined. The observation is perhaps best made in the interference figure in convergent light. When the crystal is in the parallel position, with respect to the planes of the nicols, the black cross is appreciably opened and a slight revolution is necessary to produce a definite cross. In a section showing normal emergence of an optic axis a similar effect is obtained. The one end of the black bar is appreciably curved when the crystal is in the parallel position and a slight revolution is required to obtain a straight bar. In other positions in the "ortho" zone the extinction is sensibly parallel.

These observations do not furnish absolutely convincing evidence of inclined extinction in wollastonite, for anomalous optical behavior resulting from various causes, such as strain, could produce this result. Nevertheless, they furnish adequate justification for urging that mineralogists carefully observe these relations in wollastonite wherever encountered.

In vogtite Hallimond found an extinction angle of 5° in a section normal to the acute bisectrix and parallel extinction in a section normal to the obtuse bisectrix.[7] Hlawatsch observed an extinction $\beta \wedge b$ of 9°–14°.[8]

SIGNIFICANCE OF ISOMORPHISM OF VOGTITE AND WOLLASTONITE

Whether the crystallographic similarity of wollastonite and vogtite indicates a solid solution relation is a question that may now be

[6] From the U. S. National Museum through the courtesy of Dr. W. F. Foshag who also called my attention to Eakle's description of them and their triclinic aspect.

[7] Hallimond, A. F., Op. cit., p. 369.

[8] Hlawatsch, C., Op. cit., p. 590.

raised. In view of the discovery that wollastonite is triclinic there is no objection on the ground of a difference of crystal system. However, an isomorphous relation does not necessarily indicate a solid solution relation. We may recall only the case of $CaCO_3$ and $CaMg(CO_3)_2$ which are isomorphous, i.e. similar in forms and angles, but there is no series of carbonates of intermediate composition. The relation between wollastonite and vogtite might be of a similar character.

In this connection it is desirable to note the recent studies of manganese-bearing triclinic pyroxenes by Sundius. As a result of his painstaking study of bustamites Sundius concludes that they are simply manganese-bearing wollastonites, i.e., wollastonite solid solutions.[9] Nothing is known of the crystallography of bustamite except the cleavage angle, and Sundius's conclusion is based on his demonstration that the observed variation in optical properties (including orientation of indicatrix) of the known series of bustamites, when extrapolated to zero content of $MnSiO_3$, gives, sensibly, the properties of wollastonite. Unfortunately the amount of extrapolation is some three times the extension of the known series of bustamites. The existence of this wide gap in the supposed series rather weakens the conclusion, indeed bustamites cluster so closely around a 1:1 ratio of $CaSiO_3$ to $MnSiO_3$ that one is led to wonder whether the relation between wollastonite and bustamite is not similar to that between calcite and dolomite. Sundius attempts to explain the existence of the hiatus with the aid of a subsidiary assumption regarding the character of the equilibrium diagram which he regards as rendering unlikely the formation of intermediate representatives of the series although the full series really exists. The considerations that he raises in that connection will not, however, bear critical examination, and the existence of the wide gap between wollastonite and bustamite remains unexplained if bustamite really is a wollastonite. These objections to certain aspects of Sundius's reasoning are pointed out merely because it is considered desirable that any weakness his conclusions may have should be fully brought out. It is not with the plan in mind of offering an opposed conclusion. On the contrary it is believed that Sundius has almost certainly reached the correct conclusion when he states that bustamite is merely a manganese-bearing wollastonite and that all gradations of composition can exist. The reasons for this belief come from purely collateral evidence. In a study of the system, CaO-FeO-SiO_2, now completed[10] it has been found that a continuous series

[9] Sundius, N., Am. Mineral., vol. 16, pp. 421–423, 1931.

[10] By Bowen, Schairer, and Posnjak, soon to be published.

of iron-bearing wollastonites is obtained; indeed, it was to prepare the ground for a description of this series that the present paper discussing related materials has been written. From this continuous series of wollastonites bearing iron it is but a short step to the vogtites bearing manganese as well as iron, and from these again but another step to bustamites with manganese predominating and iron unimportant. They are probably all just wollastonites.

The full evidence regarding the series of iron-bearing wollastonites will be given in the paper detailing the equilibrium studies on the system, CaO-FeO-SiO_2, and will include the evidence of optical properties and of X-ray diffraction spectra. The results obtained for vogtite and bustamite by these methods will then be given for comparison.

SUMMARY

Vogtite is a silicate formed in slags and shown by Hallimond to have the general formula (Ca, Fe, Mn, Mg) SiO_3. In the Hallimond example Ca exceeded any one of the other basic elements but was very much less than their sum. Both Hlawatsch and Hallimond made crystallographic studies and found the crystals to be triclinic. Their measurements of interfacial angles agree, but Hallimond chose a different orientation from that previously chosen by Hlawatsch with correspondence only in the position of the *c* axis (prism zone).

If vogtite is oriented in such a way that the prism zone corresponds with the ortho-zone of wollastonite a remarkable agreement is found in forms and angles of the two species. The extent of this agreement is brought out in Table 2. Wollastonite itself, as a result of X-ray studies, is now known to be triclinic and its new constants have been determined. Vogtite is therefore to be referred to a similar system of axes. The values are:

Wollastonite $a:b:c = 1.083:1:0.967$, $\alpha = 90°$, $\beta = 95°16'$, $\gamma = 103°25'$

Vogtite $a:b:c = 1.076:1:0.964$, $\alpha = 90°43'$, $\beta = 95°10'$, $\gamma = 103°35'$

The isomorphism of wollastonite and vogtite is of interest in connection with the problem of bustamite. Although isomorphism alone does not necessitate the existence of solid solution there are the strongest reasons for believing that vogtite is simply a wollastonite solid solution and the likelihood that bustamite is also a wollastonite, as Sundius maintains, becomes very great.

ZOOLOGY.—*A new genus for the nematode* Filaria cistudinis *Leidy, 1856, of the family Filariidae.*[1] JOSEPH E. ALICATA, Bureau of Animal Industry. (Communicated by BENJAMIN SCHWARTZ.)

The material on which the discussion of the nematodes described in this paper is based, consists of a male and two females collected by the writer from the heart cavities of a turtle, *Terrapene carolina.* The host animal was captured in June, 1932, in the vicinity of Washington, D. C. The nematodes in question belong to the family Filariidae Baird, 1853, emend. Claus, 1885, and to the subfamily Aproctinae Yorke and Maplestone, 1926, and possess characters which differ from those of any of the existing genera of the subfamily. They are accordingly considered as constituting a new genus for which the name *Cardianema* is proposed.

The filarids discussed in this paper are probably identical with the species reported by Leidy (1856) as *Filaria cistudinis* from the heart of the same species of turtle, *Terrapene carolina,* presumably collected in Pennsylvania. Leidy's description of the form reported by him is as follows: "*Filaria cistudinis.* Body capillary, spirally involute, attenuated at the extremities. Head and tail obtusely rounded. Mouth unarmed. Anus terminal. Length $1\frac{1}{2}$ inches, breadth $\frac{1}{6}$ of a line. One specimen was obtained by Mr. Schafhirt from the heart of *Cistudo carolina.*" Although Leidy's description is meager, the occurrence in the same host and the same location, both in the eastern United States, and the general appearance of the worms, which shows a similarity between the form described by Leidy and those found by the writer, indicate that the writer's material is *Filaria cistudinis.* The only detail in Leidy's description which does not apply to the writer's specimens is the position of the anus. Leidy, as noted above, reports the anus as terminal; the present writer finds that it is located some distance from the tip of the tail. Because the anus of this parasite, and of filarids generally, is inconspicuous and rather easily overlooked, it is probable that Leidy actually overlooked the anus, and that he mistook a cuticular structure or indentation for the anus. The specific name proposed by Leidy for the turtle heart-filarid is retained in this paper, the name of the species becoming *Cardianema cistudinis* (Leidy, 1856).

The systematic position of the parasite is as follows:

Subfamily APROCTINAE Yorke and Maplestone, 1926

Subfamily diagnosis.—Filariidae: Mouth simple, usually without lips;

[1] Received October 5, 1932.

cuticle smooth or with longitudinal or transverse striations; trident-like structures on each side of anterior end of esophagus absent; vulva anterior, or slightly posterior, to terminal portion of esophagus; spicules relatively short, equal or subequal, and similar; anus usually not functional, sometimes absent.

The position of the genus *Cardianema* in the subfamily Aproctinae and the relationship of this genus to the other known genera of this subfamily are shown in the following key:

Key to genera of subfamily Aproctinae

The genera included in this subfamily, with their distinguishing characters, have been taken for the most part from Yorke and Maplestone's (1926) key.

1. Anterior portion of spicules tubular and chitinous, posterior portion twisted and membranous; parasites of circulatory system of turtles .... *Cardianema*
   Spicules not divided into tubular and membranous portions 2
2. Males with caudal alae; parasites of muscles and tendons of legs of birds .... *Pelecitus*
   Males without caudal alae 3
3. Amphidelphic 4
   Opistodelphic 5
4. Mouth surrounded by a cuticular collar; parasites of subcutaneous tissue of birds .... *Squamofilaria*
   Mouth simple, without a cuticular collar; parasites of body cavity of birds .... *Chandlerella*
5. Esophagus very narrow and transparent; parasites of subcutaneous tissue of birds .... *Eufilaria*
   Esophagus of ordinary type 6
6. Posterior extremity of both sexes digitiform and prolonged considerably beyond anus; parasites of subcutaneous connective tissue of geckos .... *Thamugadia*
   Posterior extremity of both sexes terminating very close to tip of tail . . 7
7. Esophagus divided into a short anterior narrow portion, and a long posterior wider portion; parasites of mesentery of lizards . . . . . *Saurositus*
   Esophagus not divided into two distinct portions 8
8. Gubernaculum absent; parasites of orbital and nasal cavities of birds .... *Aprocta*
   Gubernaculum present; parasites of birds; location unknown .... *Pseudaprocta*

Cardianema, new genus

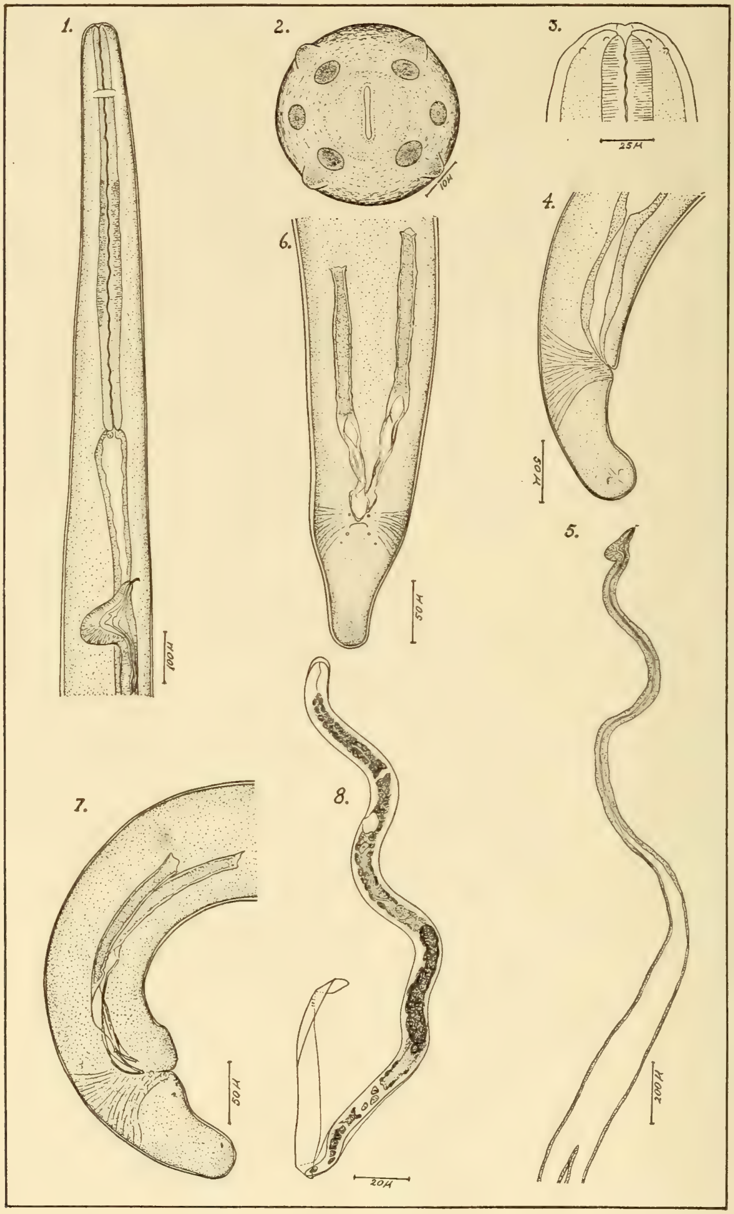
Generic diagnosis.—Aproctinae: Long and slender worms, whitish in color, loosely coiled, and attenuated toward extremities. Cuticle with fine longitudinal striations. Mouth simple, elongated dorso-ventrally, surrounded by 4 pairs of submedian papillae and a pair of lateral papillae or amphids. Esophagus simple, relatively long and slender. *Male* with slender, subequal spicules, consisting of an anterior tubular portion and a posterior membranous portion, the latter terminating in a spade-like tip. Caudal papillae small and indistinct, consisting apparently of one pair of pre-anal and two

pairs of post-anal papillae. Tail relatively long, bluntly rounded terminally, and curved ventrally. *Female* vulva slightly posterior to terminal portion of esophagus. Vagina in two parts, an anterior portion or true vagina, which is short, wide and sac-like, and a posterior portion or uterine vagina, which is tubular and slender for most of its length, but widens as it unites with two parallel uteri. Uterus opistodelphic; worms ovoviviparous, uterus containing eggs and larvae. Tail relatively long, bluntly rounded terminally, and curved ventrally. Microfilariae sheathed and occurring in the blood.

The distinguishing features of the genus *Cardianema* are: The spicules are not uniform in structure as are those of other genera of the subfamily; in *Cardianema* each spicule is made up of three distinct parts, namely, a straight, tubular, well chitinized proximal portion, followed by a transparent, twisted membranous median portion, and a terminal spade-like posterior portion. Of the genera of Aproctinae, six are parasites of birds, while the two remaining genera, *Saurositus* and *Thamugadia*, each represented by one species, are parasites of lizards. It should also be noted that *Cardianema* is apparently the only member of the Aproctinae occurring in the circulatory system. The other members of the subfamily have been found in other locations as shown in the key to the genera of Aproctinae.

Cardianema cistudinis (Leidy, 1856)

Specific diagnosis.—Cardianema: Characters of the genus. Worms slender, filiform and loosely coiled. Head rounded, and provided with 4 pairs of submedian papillae and one pair of lateral papillae or amphids (Figs. 2 and 3). Esophagus relatively long and slender (Fig. 1). *Male* (description based on writer's one specimen) 2.5 cm. long and 235μ in maximum width near equator of body. Esophagus 873μ long by 34μ in maximum width. Nerve ring 159μ from anterior extremity. Excretory pore not observed. Spicules (Figs. 6 and 7) subequal; right spicule 201μ long, consisting of a chitinized proximal tubular portion 117μ long, a median membranous portion 53μ long, and a spade-like posterior tip 31μ long; left spicule longer than right spicule, 221μ long, proximal tubular portion 129μ long, membranous portion 72μ long, and spade-like tip, which is smaller than that of right spicule, 19μ long. Cloaca 86μ from tip of tail; muscles surrounding cloaca prominent; papillae surrounding cloaca small and indistinct; one pair of pre-anal and two pairs of post-anal papillae observed. Tail directed ventrad (Fig. 7). *Female* (description based on writer's two specimens) 2.7 to 3.2 cm. long by 266 to 288μ in maximum width near middle of body. Esophagus 775 to 988μ long and 42 to 53μ in maximum width. Nerve ring 125 to 152μ from anterior extremity. Excretory pore not observed. Vulva (Figs. 1 and 5) opens just below terminal portion of esophagus, 1.107 to 1.28 mm. from anterior end. According to measurements of one specimen, true vagina (Fig. 5) short and sac-like, 150μ long by 91μ wide; uterine vagina tubular, 2.2 mm. long, 45μ wide at junction with sac-like portion of true vagina, and widening to 144μ at the point where it joins the two uteri. Uteri contain eggs and larvae; eggs in uteri oval, about 26μ long and 11 to 15μ wide. Two larvae *in utero* were 225μ long and 9μ in maximum width, which corresponds approximately to size of larvae found in blood. Anus small, 99μ from tip of tail; muscles surrounding anus prominent. Tail curved ventrad; tip bluntly rounded (Fig. 4).



Cardianema cistudinis.—1. Female, anterior portion (ventro-lateral view); 2. Female, anterior end (*en face* view); 3. Female, anterior end (ventral view); 4. Female, posterior portion (lateral view); 5. Female, showing vulva, true-vagina, uterine vagina and beginning of uteri; 6. Male, posterior portion (ventral view); 7. Male, posterior portion (lateral view); 8. Microfilaria from the blood.

Microfilariae from heart blood were stained with Wright's stain. Smears made by rubbing pieces of liver on slides revealed numerous ensheathed microfilariae in blood of liver also. Two small, oval, pearly cysts, 740 to 780μ long by 289 to 305μ wide, found on the surface of the liver, were opened with dissecting needles, and found to be tough connective tissue cysts, 15μ thick, each containing a microfilaria; this finding of microfilaria in cysts appears to be unusual, but probably represents a defense reaction of a customary sort, commonly invoked against other parasites and perhaps invoked against microfilariae oftener than is supposed.

Microfilariae (Fig. 8) inclosed within a sheath which is considerably longer than the worm it contains. Larvae, excluding sheath, 190 to 280μ long by 9 to 12μ in maximum width. Anterior extremity bluntly rounded; body more or less uniform in width up to a point slightly posterior to the granular mass, tapering gradually from this point and terminating in a somewhat short digitiform tail. The anterior extremity of the larva did not take stain. Following a short area of a stained portion is the nerve ring which appears as an obliquely unstained band extending across width of body, 42 to 65μ from anterior extremity. So-called "V spot," or excretory pore, opens to outside 10 to 20μ posterior to nerve ring; excretory cell just posterior to excretory pore. Approximately at equator of body, 90 to 135μ from anterior end, is beginning of so-called granular mass, a dark purple-stained area, extending postequatorially 35 to 60μ. Of what appear to be the genital cells the first one is immediately posterior to granular mass, the second about 18μ posterior to first cell, and the third and fourth cells arranged one behind the

TABLE 1. DIMENSIONS (IN MICRONS) AND PROPORTIONS OF SEVEN CARDIANEMA CISTUDINIS LARVAE FROM THE BLOOD OF TERRAPENE CAROLINA

	1	2	3	4	5	6	7
(1) Length (without sheath)....	190	200	210	220	240	268	280
(2) Maximum width..........	9	9	11	11	11	12	12
(3) Distance from anterior extremity to nerve ring.....	42	45	45	48	57	62	65
(4) Distance from nerve ring to excretory pore...........	10	10	15	15	15	20	20
(5) Length of tail..............	14	20	20	23	23	23	28
(6) Percentage of body length anterior to nerve ring.....	22.1	20.5	21.4	21.8	23.7	23.1	23.2
(7) Percentage of body length anterior to excretory pore.	27.3	27.5	28.5	28.6	30	30.5	30.3
(8) Difference between (7) and (6)....................	5.2	7	7.1	6.8	6.3	7.4	7.1
(9) Percentage of body length anterior to tail..........	92.6	90	90.4	89.5	90.4	91.4	90
(10) Distance from anterior extremity to granular mass..	90	100	108	115	120	125	135
(11) Length of granular mass....	40	35	38	45	42	45	60

other shortly posterior to second cell. The so-called tail-spot, another unstained area, is 14 to 28μ from tip of tail. Tail contains few stained elements.

Host.—Definitive: Turtle (*Terrapene carolina*); intermediate: unknown.

Location.—Adults in cavities of heart; ensheathed larvae in blood of primary host.

Distribution.—United States (Pennsylvania ?) and vicinity of Washington, D. C.

Specimens.—U. S. N. M. Helm. Coll. No. 32604.

Table 1 shows the principal measurements of seven larvae, and certain size relationships in percentages.

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ZOOLOGY.—*Egg-laying habits and larval stages of a milliped,* Arctobolus marginatus *(Say) Cook, native at Washington.*[1] H. F. Loomis, Bureau of Plant Industry. (Communicated by O. F. Cook.)

Early in the summer of 1916, Mr. H. S. Barber, of the U. S. National Museum, was collecting insects in the woods on the Virginia shore of the Potomac River at Plummer's Island, a short distance above the city of Washington, when beneath the loose bark of a fallen tree he discovered a female milliped of the large, cylindrical, native species, *Arctobolus marginatus* (Say) Cook, in the act of laying her eggs. As soon as he realized what the milliped was doing he replaced the bark without disturbing her, and ceased further investigation of the log. Several days later, on June 2, I visited the same spot with Mr. Barber and we began a careful search of the rotting tree trunk for millipeds or their eggs, both of which were found to be numerous,

[1] The notes forming the basis for this paper were made a number of years ago and are far from complete, but deal with interesting phases in the life history of an animal belonging to a little-known group of arthropods. As an opportunity for continuing the study may not present itself again it seems desirable to put these observations on record. Received October 5, 1932.

as also were recently hatched young. The bark loosely covered the partially rotted interior, into which the millipeds had worked their way, and by the movement of their bodies had formed small chambers in the soft material. In some of these chambers the females had begun to lay eggs, whereas in others egg-laying had not started. Of all the millipeds found in this log, none were males. Likewise, in a search of the leaf-mould in the vicinity only females of this species were found and some of these also were laying.

On this visit no attempt was made at detailed observations, but gravid female millipeds, eggs, and recently hatched young were placed in tin boxes with a quantity of the moist, rotten wood, for further study.

Some of the females had already laid part of their eggs in the log but others apparently had not begun to lay, so that a count of the eggs subsequently laid in the individual boxes in which the females were kept gave an indication of the number of eggs that might be produced by a female at one "nesting." The greatest number of eggs laid by any one of these females was 261, while seven others produced the following numbers—216, 204, 203, 189, 186, 153, 74. These eggs were deposited between June 2 and 11, after which no more eggs were laid.

From observations on the imprisoned millipeds and those in natural surroundings it was apparent that this species had a definite egg-laying season, but there may have been at least one other such period in the fall, for on August 4, 1916, Mr. Barber noted numbers of these millipeds in the same locality mating on the tree trunks at night, and it is supposed that the eggs then fertilized were laid a few weeks later, instead of being held through the winter for laying the following spring, ten months after fertilization. Also it is probable that these were of the same generation of females which had been seen laying eggs in early June.

In this species of milliped it was found that the mother enclosed each egg in an individual pellet composed of what was, at first, thought to be the material constituting the excrement pellets, but closer examination showed the egg pellets to be of a lighter colored, coarser substance, containing tiny fragments of rotten wood, leaves, (and fungi?). Several times, by carefully opening the tin containers, the millipeds were caught in the act of forming these egg cases and were watched undisturbed practically throughout the entire process of encasing the egg in the pellet.

The first step in the manufacture of one of these egg cases was the

regurgitation of a small mass of material by the mother, who curved her head so that the mass was delivered to the legs a short distance behind the head, the eighth to eleventh pairs of legs receiving the moist lump. These legs held the mass while the milliped curved her head around still further and began flattening and spreading the material by repeatedly forcing the smooth, convex front of her head against it, until soon there was formed a thin saucer or shallow bowl, smoothed on the convex side by the milliped's head, but with a rough exterior. In the center of this saucer the egg was placed immediately following its ejection from one of the paired oviducts which in millipeds, contrary to what might be expected from the position of the oviducts in most other arthropods, are located just behind the second segment, at the front of the body. The actual placing of the egg in the saucer was not observed but probably was accomplished by the mother's bending her body over the saucer and laying the egg directly in it, although it might have been possible to have the egg passed back from the oviduct and placed in the saucer by the legs between the oviduct and those holding the receptacle. As soon as the egg was deposited, the edges of the saucer were brought up and kneaded together by the feet, while the junction was rapidly worked over by the front edge of the head or labrum, and this action of head and feet was continued until an almost perfect sphere, with a slightly roughened surface but without folds or cracks, was formed. The completed pellet was dropped by the mother and she soon began a repetition of the process for the next egg.

The completed egg pellets measured 3 to 3.5 mm. in diameter, with walls slightly less than a millimeter thick, leaving the egg lying loose in a chamber 1.5 to 1.8 mm. in diameter. The egg pellets were somewhat intermixed with excrement pellets but were distinguished from them by being nearly round, by having a rougher surface caused by the varied material from which they were made, and by the fact that these pellets, when exposed to the air, dried to a light brown color much faster than the excrement pellets, which had a finer texture that held moisture better, were oval in shape, and whose surfaces were smoother. The walls of the egg pellets formed the first food eaten by the young millipeds; each pellet containing enough food to last the milliped through several of its earliest stages of growth.

Occasionally the egg-laying and pellet-making processes were not conducted with routine exactness as was shown in one pellet where two eggs had been deposited by the mother, one being left slightly

exposed and forming part of the surface of the pellet. In another pellet the egg was visible through a carefully rounded, smooth-edged hole in the side, which possibly was left because of insufficient material to complete the pellet. At another time the mother had fashioned a pellet which outwardly was indistinguishable from the other egg pellets, but on breaking this pellet it appeared that no egg had been deposited in the perfectly moulded chamber.

The eggs were creamy white in color and broadly oval in shape, being about 1.3 mm. in their longest diameter and 1.1 mm. in the shortest diameter. All descriptions that have been noted in milliped literature refer to the eggs of millipeds as being round instead of oval. Moreover, all the eggs that have been found by the writer in collecting these animals have also been round, with this one exception. The formation of an edible pellet about each egg does not appear to have been reported for any other milliped, and from a quotation on a succeeding page, from a paper by J. W. Bailey, it appears that this custom is not followed throughout even the genus *Arctobolus*. Millipeds belonging to some of the other orders make definite nests in which they lay their eggs, but the eggs are not placed in individually manufactured cells, nor is any provision made by the mother for supplying the newly hatched young with food.

The egg pellets made by each of the females imprisoned in the tin boxes on June 2 were removed several days later and placed in separate boxes where they were examined from time to time. On July 9, first stage "larval" millipeds were found by breaking the egg pellets and a few second and third stage young were also seen there. Although some of these young necessarily had been present in previous examinations of the boxes they had been overlooked because it was expected that the young millipeds would emerge from the pellets as soon as they were born, whereas it was first discovered on July 9 that the young millipeds normally remained in the pellets for a considerable time after hatching and there underwent several changes. Subsequently it was determined that they remained in the pellets throughout the first two stages of their life and finally ate their way out during the third stage—usually in the latter part of this stage—when nearing the time for the third moult. Eggs continued to hatch until July 13, on which date no unhatched eggs could be found in the tins and there were only about a quarter as many millipeds in the first stage of growth as in either the second or third stages, indicating that the majority of the eggs had hatched considerably before this

date. From the rather limited observations it appeared that the period of incubation lasted from three to five weeks, but no very conclusive data were obtained.

The incubation period of the eggs in the tin boxes manifestly was about a week less than for similar eggs left in the log from which came the females used for observation. Warmer temperatures doubt-

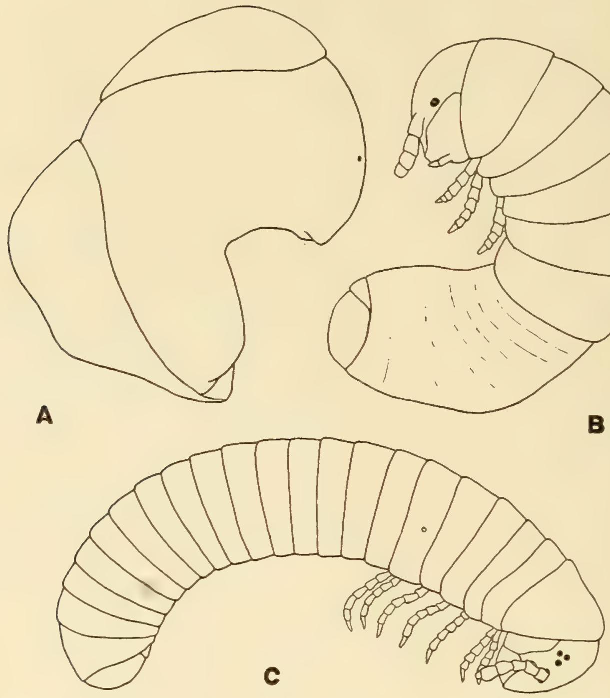

Fig. 1.—Three stages of *Arctobolus marginatus*. A. First stage, with portions of the egg-shell still adhering, head and segments not differentiated, the eye spot faintly indicated, the appendages still unformed. B. Second stage, with 6 definite segments and 3 pairs of legs. C. Third stage, with 21 segments and 7 pairs of legs.

lessly accounted for the more rapid incubation of the eggs in the tin boxes. Hence, it was assumed that from four to six weeks usually were required for the incubation of the eggs of this milliped under natural conditions.

When an egg hatched the shell usually split almost all the way around the middle, forming subequal halves narrowly joined together, the halves opening up, like a clam, exposing the young milliped in its first stage of life. During this stage the brownish eggshell

was not cast off but remained on the back of the milliped until the first moult had taken place.

Contrary to statements found in zoological text books and scientific papers on immature millipeds, the first stage "larva" of *A. marginatus* did not have a distinct head followed by definite segments, and there were no legs or antennae visible. Instead, the animal appeared as a short, white grub, somewhat angular in the region of the mouthparts; covered by a very delicate semi-transparent membrane or skin of uniform texture, through which a single eyespot on each side of the head and a suggestion of segments could be seen (Fig. 1). Although this skin was retained by the animal until the first moult it did not appear to be attached to the animal and was removed from several of the young to allow direct examination of them. They were found to have a distinct head and six well-formed segments, followed by a slightly swollen, abdomen-like portion, composed of indistinct rings, terminating in a soft but rather evident, truncate last segment containing well-defined anal valves and preanal scale. A brownish eyespot was found on each side of the head although this did not develop to a normal ocellus until the moult. The very short antennae appeared to be indistinctly 4-jointed, but the mouthparts were soft, unchitinized, and amorphous, and it was doubtful if the animals ate anything during this stage. There were no legs, but on segments 1, 2, and 3, small, elevated prominences or tubercles were noted in the locations where the legs would develop at the first moult.

The period of time passed by the animals in this first stage and in succeeding stages was not determined as the writer's unexpected departure from Washington occurred before the study of this feature of development was well under way.

Following the first moult, in the second stage of their existence, the young millipeds were short, white in color, and each had a well-developed ocellus on either side of the head, in addition to which, at times, there were two brownish eyespots which would develop into ocelli at the second moult. The mouthparts were of definite shape and moderately chitinized, and the mandibulary stipes slightly hollowed to receive the antennae. The antennae were quite short and capable of being somewhat telescoped, and there were five joints, with the four apical sense cones readily seen. Behind the head were six well-developed and definitely chitinized body segments, each of the first three with a pair of 6-jointed legs, as in mature individuals; the legs terminating in a strong, appendiculate claw, the needle-like appendage of which was below and nearly half the length of the main part

of the claw. All the joints of the legs had one or two strong setae on the ventral face. Segment 6 of the body had no indication of repugnatorial pores. The posterior half of the body resembled a soft, indistinctly ringed abdomen, with the last segment, valves, and preanal scale as described for the first stage young.

In the third stage, which succeeded the second moult, the still uncolored young millipeds could no longer be mistaken for insect larvae as they had a strongly chitinized body, composed of twenty-one distinct segments, infrequently twenty-two segments, and each of the first five of these bore a single pair of legs, while segment 6 bore two pairs of legs. The ensuing segments constituted two-thirds of the length of the body and were footless and showed no indication of where the legs to be added at the next moult would come. The second segment was not produced forward below segment 1, as it would be in after life. The last segment, anal valves, and preanal scale were shaped as in mature animals. A repugnatorial pore was visible on each side of segment 6 but there was no indication of pores on the segments thereafter. The antennae had six distinct joints, and the three fully developed ocelli formed a triangle on each side of the head; the mandibulary stipes were deeply excavated for the reception of the antennae. It was when nearing the end of this stage that the millipeds ate their way out of the food pellets made by the mother when the eggs were laid.

The fourth stage millipeds had twenty-six or twenty-seven segments and, in either case, the last six segments were legless. Thus females had thirty-five or thirty-seven pairs of legs, as the first five segments each had one pair of legs while the succeeding segments each had two pairs as far as the legs extended. Although many fourth stage millipeds were examined no males were detected, but it is possible that they would have had thirty-three or thirty-five pairs of legs, for the leg arrangement would be the same as for females except that segment 7 probably would be without legs because in the final stages of growth the males have the legs of this segment greatly modified and hidden within the body, the structures generally being referred to as "gonopods" and only functioning during mating. The animals were light brown, finely mottled with uncolored spots above and below, except on the posterior legless segments which were uncolored. In this stage the forward production of the second segment below the corner of segment 1, so evident in mature individuals, was first observed. The repugnatorial pores were present from segment 6 to the last pedigerous segment inclusive. The antennae had six obvious

joints, and on each side of the head six ocelli usually formed an equilateral triangle, but in some specimens the number of ocelli in each eye was reduced to three or four.

The structural notes on the growth stages following the fourth moult were never completed, but segment counts of a small number of young millipeds indicated that there were at least three more stages before maturity was reached.

Millipeds in the fifth stage had thirty-two segments, and their eyes were composed of eight to ten ocelli.

Of eight sixth-stage young, two had thirty-six segments, four had thirty-seven segments, and two had thirty-eight segments; the ocelli numbered thirteen to fifteen, with one individual in which there were but eight ocelli on one side of the head and ten ocelli on the other.

In what was assumed to be the seventh stage, three millipeds had forty-one segments, one had forty-three segments, and three had forty-four segments, and the ocelli ranged from eighteen to twenty-one.

Mature specimens of this species have been reported with forty-seven to fifty-seven segments and thirty to forty ocelli composing each eye. Those examined by the writer usually had between fifty and fifty-five segments and thirty-six to forty-three ocelli. In view of these figures it is probable that an eighth and possibly a ninth stage occurs in the life history of this species before maturity is reached.

In regard to the moulting of these millipeds, particularly in the early stages, it was observed that just prior to the moult the posterior legless portion of the body became noticeably elongated, with the segments considerably exposed, as much as the pedigerous segments, whereas after the moult these legless segments were strongly telescoped and hidden within each other, and the body was a lighter color than immediately preceding the moult. Following the moult the body remained quite soft for a day or two but gradually hardened and, in the later growth stages, assumed an increasingly darker color.

In early May several years prior to the observations reported in this paper, H. S. Barber, interested in the life history of *A. marginatus* in relation to the food habits of the giant glow-worm, *Phengodes laticollis* Lec. endeavored to find where and how the eggs of this milliped were laid by placing about twenty full grown specimens of both sexes in a deep jar set in the ground and filled with leaf-litter for food. His subsequent observations are quoted below.

"By the end of July young had appeared in the jar although it had previously been examined without finding eggs. At this time, however, it was

discovered that in most cases the excrement pellets were not solid but consisted merely of a thin shell surrounding a comparatively large cavity in which the small brown-skinned egg was lying loose. These pellets showed no external difference from the solid normal pellets cast by large individuals of the species, but when exposed to the air for a few minutes the color changed slightly on account of the more rapid drying out of the thin shell. About a pint of both kinds of pellets was placed in tin boxes where they could be frequently examined. By the middle of August most of the young myriapods had devoured their enclosing pellets and were feeding on the solid ones. They measured 8 mm. in length and had seven pairs of legs, but some were moulting into a slightly longer, many-legged (35 pairs) form. Before the middle of September they had reduced all of the frass pellets in the tin into a mass of very fine frass and were crawling on its surface seeking other food. They congregated on bits of rotten wood that were introduced and began feeding, but the condition of this rotten wood was apparently unsuitable, and a few days later all were found dead on the surface, many having had all their legs eaten off by those who survived the longest."[2]

Several points of divergence may be noted which partly arose from the fact that the egg-laying habits had not been observed. Also it is appropriate to note the observations of another writer on what is probably a different species of the genus *Arctobolus* although referred to *marginatus.*

J. W. Bailey[3] listed *Spirobolus marginatus* as the only species known to occur in the state, and on page 13 made the following statements in discussing the habits of the Diplopoda.

"*Spirobolus*, one of the most common and the largest of the Diplopoda found in New York State, deposits its eggs in damp, wet places, usually in some decaying stump or fallen log. The pearly white eggs, about the size of a small buckshot, are deposited in June, July and August; usually 15 to 20 in a batch. The eggs are never covered with dirt, as in *Julus* or other species. The period of incubation is said to be ten to 18 days. The young emerge from the eggs as partially developed larvalike creatures having only three pairs of appendages as do other members of the class Diplopoda."

That the true *Arctobolus* (*Spirobolus*) *marginatus* is not native to New York State, but is a more southern species, was pointed out by O. F. Cook in describing *A. onondaga,* from Onondaga County, New York, as the type of the genus.[4] The strikingly different egg-laying habits of the New York species is an additional reason to consider it distinct from *marginatus,* but its identity with *onondaga* cannot be

[2] Barber, H. S., Fragmentary notes on the life history of the Myriapod, *Spirobolus marginatus:* Proc. Ent. Soc. Wash., vol. 17, no. 3, 1915.

[3] Bailey, J. W., The Chilopoda of New York State with notes on the Diplopoda: N. Y. State Mus. Bull. 276, 1928.

[4] Cook, O. F., Myriapoda of northwestern North America: Harriman Alaska Exped., pp. 64–65, 1904.

certified without comparing specimens with the description or the type specimen of *onondaga*.

East of the Mississippi, principally in the South Eastern and South Central states, there are about eight recognized species of millipeds belonging to the genus *Arctobolus;* whereas west of the Mississippi closely allied genera contain about the same number of species. In view of the differences in egg-laying habits between the New York species and the one about Washington, variation of the same habits of the other species undoubtedly occur, and investigation of these species should furnish interesting facts, which conceivably might also be of value in determining the systematic relationships of the species.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

493D MEETING

The 493d meeting was held at the Cosmos Club October 26, 1932, Vice-President HESS presiding.

Informal Communications.—W. C. MANSFIELD in company with Mr. HERMAN GUNTER, State Geologist of Florida, upon a recent trip up the Suwanee River, discovered, about a mile and a half upstream from White Springs, an unconformity between the tampa limestone and the sandstone of the overlying Hawthorne formation.

H. D. MISER described three sink-hole deposits in Ordovician limestone, all near Rolla, Missouri. One sink-hole contained flint clay with diaspore; another contained deposits of limonite, hematite, and magnetite, all probably derived from pyrite; and the third sink-hole contained coal of Pennsylvanian age. The coal deposit has the form of a vertical column 90 feet in diameter and 180 feet long, and is entirely surrounded by fire clay. All three deposits have been worked commercially.

Program: N. H. DARTON: *New geologic map of Texas.*

C. WYTHE COOKE: *Pleistocene changes of sea level.*—The alternating accumulation and melting of the continental ice caps during the Pleistocene epoch caused repeated fluctuations of sea level amounting to several hundreds of feet in amplitude. The sea was low during the glacial stages and high during the interglacial stages. During each resting stage that was of sufficient duration the sea engraved a high-water mark or a low-water mark on the land and thus recorded the position of its shore at various stages. But the height of sea level is also affected by any crustal movements that change the capacity of the oceanic basins. Therefore, the present altitude of the high-water marks or abandoned shore lines can not be attributed ex-

clusively to glacial control, for they record the net lowering of sea level due to all causes. The high-water marks now stand about 12, 25, 42, 70, 100, 170, 215, and 270 feet above the present sea level except where they have been deformed by Pleistocene or Recent movements of the land.

Eustatic shore lines make very useful datum planes by which to correlate the various phases of Pleistocene history because they encircle all continents and islands. It may be possible to correlate the glacial and interglacial stages in different parts of the world by the reference of each stage to its corresponding shore line. The discovery by Leverett of pebbles washed out of the Illinoian moraine in the deposits of the 100-foot stage (Wicomico formation) shows that the 100-foot shore line can not be older than Sangamon interglacial time, which immediately followed the Illinoian glaciation. From this as a starting point one can arrive at a hypothetical correlation of the shore lines with the interglacial stages by assigning each successive shore line above 100 feet to an interglacial stage successively older than the Sangamon and each successive shore line lower than 100 feet to a successively younger interglacial stage. This disposes of every definitely recognized Pleistocene shore except the 12-foot, which is attributed to lowering of sea level from some cause other than glacial control. The 42-foot and the 25-foot shore lines are tentatively correlated with the first and second interglacial substages of the Wisconsin, respectively. As glacial geologists think that the polar ice caps during these temporary retreats of the Wisconsin ice were larger than the existing ice caps, glacial control alone may not account for any of the lowering that leaves them high and dry today.

A series of seven paleogeographic maps of South Carolina shows that the shore line at each stage of the sea differed markedly from those that came before and after. The shore of the 70-foot stage, which is tentatively correlated with the Peorian, gives evidence of long-continued stability of the sea at that level. Much of the erosion that dissected the region of the Sea Islands appears to have taken place during the low-water stage of the first Wisconsin glaciation. (*Author's abstract.*)

Discussed by Mr. W. C. Mansfield.

Hugh D. Miser: *Oklahoma structural salient of the Ouachita Mountains.*—The Oklahoma structural salient of the Ouachita Mountains comprises their western portion, lying mostly in Oklahoma but partly in Arkansas. Its northern frontal margin, a great arc 180 miles in length, trends in a northeasterly and then easterly direction along the northern edge of the mountains in Oklahoma and then passes in a southeasterly direction across the mountains in western Arkansas. In the salient, as well as elsewhere in the mountains, a vast succession of rocks ranging in age from Cambrian to Pennsylvanian and having a thickness of 25,000 feet has been deformed by late Paleozoic folding and faulting. In Oklahoma the front of the salient is marked by thrust faults which bring together two different facies of rocks, the Ouachita Mountain facies and the Arbuckle Mountain facies. Toward

the south the rocks of the Ouachita facies pass underneath the Cretaceous rocks of the Gulf Coastal Plain and occupy a wide belt extending in a southwesterly direction into Texas, past the east side of the Central Mineral region, and thence in a westerly direction to and beyond the Marathon region. Likewise, the Oklahoma salient appears to pass into Texas, but how far it extends into that State is not determinable from the available data provided by wells that have reached the pre-Cretaceous floor.

The deformation of the rocks in the salient was produced by compressive movements from the southeast and the frontal portion of the salient appears to have been thrust northwestward a distance of 20 miles or more over the rocks of the Arbuckle Mountain facies in Oklahoma and also in northern Texas. The structural trends of the Arbuckle facies near the Red River are toward the southeast, whereas the trends in the adjacent portion of the Ouachita geosyncline are toward the southwest. It thus appears that the northwestward thrusting of the Oklahoma salient took place after the major periods of deformation of the rocks of the Arbuckle Mountain facies.

The structural features that are revealed in the Oklahoma salient are characterized by long parallel thrust faults, which bound northwestwardly-thrust nappes. The longest fault, the Choctaw, has a length of 125 miles. Toward the southwest the faults pass underneath the Cretaceous rocks of the Coastal Plain and their extent in this direction is thus not known, but toward the east the faults die out near the eastern margin of the salient and terminate near the Arkansas-Oklahoma line.

The deformation of the rocks of the portion of the Ouachita Mountains east of the salient resulted from movements from the south. Here the characteristic type of structural deformation is close folding much of which is isoclinal; there is a notable absence of thrust faulting; and all the available evidence based on structural and stratigraphic field studies by me and other geologists shows clearly that the northern margin of the Ouachita Mountain facies of rocks is not limited by thrust faults in Arkansas as it is in Oklahoma.

The presence of a portion of a salient in central Arkansas seems to be indicated by the arcuate arrangement of the structural trends between Little Rock and Hot Springs. It may be appropriately designated the Little Rock salient. The greater portion of this salient is concealed by the Cretaceous and younger deposits of the Gulf Coastal Plain.

The arcuate trends of the Ouachita geosyncline in Oklahoma and Texas, whereby it changes from west to southwest in Oklahoma and then bends toward the west in central Texas, seem to suggest that the geosyncline probably has a curved course east of the east end of the Ouachita Mountains in Arkansas. To me, it appears possible that the geosyncline passes eastward in Arkansas and thence southeastward across the Mississippi River to join the Appalachian geosyncline in Alabama. The form of the supposed Little Rock salient would be similar to the form of the Oklahoma salient. Also, the reentrant salient of the Ouachita geosyncline in central Texas would be

similar to such a salient in the geosynclinal area between Arkansas and the Appalachians in Alabama.

Deposits of erratic boulders, mostly of pre-Carboniferous rocks, are found along and near the northern margin of the Ouachita Mountains. With the exception of deposits near Boles, Scott County, Arkansas, they are all confined to the Oklahoma salient. None of the deposits is found along the thrust faults that bound the nappes and they can thus not be regarded as having a tectonic origin that is related to such faults. Instead, they are all confined to a single formation, the Caney shale of Carboniferous age. My present conclusions, which are based on field evidence that has been obtained by me over a period of many years, are that the boulders are not remnants of thrust sheets, nor are they fault breccia, but they appear to have been brought into the Ouachita geosyncline during Caney time through some unusual means of transportation, perhaps by ice rafting. The boulders thus appear to form a part of the stratigraphic sequence in the Ouachita Mountains, and do not appear to be related in origin to any structural features of the mountains. (*Author's abstract.*)

Discussed by Mr. E. O. Ulrich.

494th meeting

The 494th meeting was held at the Cosmos Club November 9, 1932, President F. E. Matthes presiding.

Informal communication.—H. G. Ferguson outlined the tentative plans for the meetings of the 16th International Geological Congress to be held in the U. S. Chamber of Commerce Building, the last week in July.

Program: C. S. Ross.—*Genesis of titanium deposits of Nelson County, Virginia.*

Discussed by Messrs. Hess, Schaller, and Gilluly.

Watson H. Monroe: *Topography and physiography from aerial photographs.*—When two photographs taken of the same area from different points and correctly oriented with respect to each other are viewed through a stereoscope, the image of the area common to both is seen in relief. Therefore, with single-lens vertical aerial photographs with a mutual overlap of 60 per cent between adjacent pictures it is possible to construct several kinds of hypsographic maps without using a machine of the aerocartograph type. A controlled form-line map intermediate in accuracy between a simple form-line map and an accurate contour map can easily be constructed at low cost of time and money. Such a map is accurate enough for most uses. Horizontal control by transit traverse and vertical control by a large number of spot elevations determined by carefully checked barometer or plane table traverse are necessary for this type of map. Form lines controlled by the spot elevations are drawn on one of two overlapping photographs viewed through a stereoscope. All features such as roads, streams, houses, railroads and the form lines are then traced on cloth with differences in scale and correct

orientation of the photographs provided for by an intersection net previously prepared. The tracing is then reduced to the desired scale by photography.

Many physiographic forms such as old land surfaces, drainage changes, submerged coastal features and land forms, that can not be seen from the ground or on topographic maps, can be understood when studied on aerial photographs.

In the northwestern part of the Jackson quadrangle, Mississippi, there has been recent dissection of an old plain, beheading of streams, and development of right-angled drainage. These features can not readily be detected from the ground and are not shown on the topographic map made in 1901.

Photographs of the Pearl River, Mississippi, swamp show a large number of lakes and sloughs scattered through the woods. The Pearl River at various stages in its history used these for its channel but has since abandoned them. Maps of the river, made in 1821 and 1901, when superimposed on a new map of the river traced from photographs, show a number of changes in the channel, but the old channel is represented by some of the lakes and sloughs. Much of the year the swamp is impenetrable and a map could not be made by ground methods alone except at a prohibitive cost.

For a comprehensive picture of the area such as that afforded by a drainage map of a large area, a mosaic is to be preferred. For detailed examination of the topography, the overlap of two adjacent photographs should be studied with a stereoscope. (*Author's abstract.*)

Discussed by Messrs. K. E. Lohman, Trask, and Matthes.

T. A. Jaggar: *Elevation changes, horizontal shift, and tilt at Kilauea Volcano.*—The cycle of rise of lava and the tumescence at Kilauea in the years 1913–1924, was followed by fall of lava and subsidence, and ended by engulfment and a steam-blast eruption in 1924, and occupied a little more than 11 years. Mauna Loa made lava gushings at the summit crater in 1914, part way down the slope in 1916, and into the sea in 1919, all within this Kilauea cycle. Sympathetic sudden sinkings of Kilauea lava occurred at the end of each Mauna Loa episode. Examination of the record of 134 years next preceding 1924, beginning with the last steam-blast eruption at Kilauea in 1790, reveals twelve evident cycles involving the Mauna Loa-Kilauea system. It also reveals a supercycle with minima of lava pressure at low levels at the beginning and end of the nineteenth century, and maxima in the middle of the period—1790–1924—and the maxima at high levels on Mauna Loa. (See Volcano Letter No. 325.)

R. M. Wilson has completed critical triangulation and levelling of Kilauea crater and vicinity during the epoch 1921–1922 and compared it with the survey of 1926–1927. It shows a lowering of the mountain top of 13 feet and horizontal inward shift of the country rock 2 to 4 feet. This was the period of the great engulfment collapse. The curve of level change bends steeply close to the inner pit, but the effects extend outward at least twenty miles.

Level changes between 1912 and 1921 show a bulging up of the mountain top differentially 1.58 feet in 4 miles at the summit region. General elevation during this high-pressure lava period was indicated but not certain, owing to critical uncertainties of rod-length and sea-level datum. Precision increased with each new survey.

Fortunately the seismographs at the northeast edge of Kilauea crater registered all tilts. These were of the order of 60 seconds outward in 1918–1920 during the rising lava period, and 70 seconds inward during the 1921–1924 collapse. Much of the latter actually accompanied the steam-blast engulfment, so that the tilt data may be profitably studied, as timing the events, indicated by comparison of the triangulation and levelling changes. Mr. Wilson's report which is to be published by the U. S. Geological Survey considers rigorously, order of precision, probable error, and absolute datum.

The Hawaiian Volcano Observatory has built three tilt cellars equally distributed about the Kilauea lava pit, and these are equipped with clinoscopes reading direction and amount of tilt daily. E. G. Wingate is in charge of this work, and also of the levelling and triangulation. (*Author's abstract.*)

495TH MEETING

The 495th meeting was held at the Cosmos Club, November 23, 1932, President F. E. MATTHES presiding.

Informal communication.—Miss TAISIA STADNICHENKO described the structure and microscopic characters of a sample of the coal from the sinkhole deposit in Missouri which Mr. MISER described at the 493d meeting of the Society. The coal is bituminous and of high rank, not laminated but more massive and canneloid in appearance. Thin sections show that it contains an abundance of spores, a subordinate amount of woody material but nevertheless a considerable quantity of fusain or mineral charcoal. It is probably not a coking coal.

W. H. BRADLEY: *Factors that determine the curvature of mud-cracked layers.*—Three factors play a predominant role in determining the curvature of polygonal, mud-cracked layers or plates; (1) the vertical grain size gradient, that is, the decrease upward (or downward) in the size of grains; (2) the presence of salt crystals; and (3) the rate of drying. Theoretical principles controlling the shrinkage of drying muds and the experimental work of students of moist soils and muds, indicate that the finer the grain size, and the greater the proportion of clayey, flake-like particles, the greater the shrinkage capacity and cohesiveness of the mud. These principles, checked by experiments and field observations, lead to the generalization that the polygonal plates of a drying mud tend to become concave toward the finest grained material and that the amount of curvature varies directly as the grain size gradient. Mud-cracked layers may become convex upward if the grain size decreases downward. This may result either from inversion of the normal decrease upward in the grain size or from the growth of salt crystals

in the upper layers whose grain size is thereby coarsened with respect to the lower layers. The ultimate effect of the rate of drying on most muds is negligible but in very fine, even grained muds the rate of drying becomes the dominant factor controlling the curvature of the dried layers. In these muds exceedingly slow drying produces either flat, or slightly concave plates, but rapid drying causes the plates to become markedly convex upward. Consequently, if salt crystals or their molds are absent, the convexity of mud-cracked layers can be used as a criterion of salinity only when the convexity owing either to rapid drying of very fine, even grained mud or to inversion of the normal grain size gradient can be definitely excluded. (*Author's abstract.*)

Discussed by Messrs. Rubey, Parker, and Thompson.

B. L. Clark: *The Mt. Diablo thrust.*

Discussed by Messrs. Stose, Woodring, Matthes, Goldman, Hendricks, Hewett, and Ferguson.

496th meeting

The 496th meeting of the Society was held at the Cosmos Club December 14, 1932, President F. E. Matthes presiding. Vice President F. L. Hess took the chair during the presentation of the presidential address: *The evolution of the glacial cirque.*

40th annual meeting

The 40th annual meeting was held at the Cosmos Club after the adjournment of the 496th regular meeting, President F. E. Matthes presiding. The annual report of the Secretaries was read. The Treasurer presented his annual report showing an excess of assets over liabilities of $1,677.50 on December 9, 1932. The auditing committee reported that the books of the Treasurer were correct.

The results of balloting for officers for the ensuing year were as follows: *President:* C. N. Fenner; *Vice-Presidents:* H. G. Ferguson and R. C. Wells; *Treasurer:* C. Wythe Cooke; *Secretaries:* W. H. Bradley and T. B. Nolan; *Members-at-large of the Council:* E. Kirk, C. E. Resser, E. T. McKnight, M. N. Bramlette, and D. G. Thompson; *Nominee as Vice-President of the Washington Academy of Sciences representing the Geological Society:* F. E. Matthes.

J. F. Schairer and W. H. Bradley, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

Washington at the Atlantic City Meetings.—Washington institutions and scientists took part in the midwinter meetings of the American Association for the Advancement of Science and affiliated societies, in Atlantic City

from December 26 to 31. Three federal departments, Agriculture, Treasury, and Commerce, displayed exhibits; and other Washington exhibitors included the Smithsonian Institution, the Carnegie Institution, Mr. Charles Bittinger, and Mr. Hugh Clark and Miss Leila G. Forbes.

The Department of Agriculture exhibit consisted of a demonstration of damage caused by the Mexican bean beetle and methods for its control, and a demonstration of the surgical use of blowfly larvae in treating infected wounds, and of methods of rearing them under aseptic conditions.

Representing the Treasury Department, the U. S. Public Health Service showed graphically how the ancient hard-times scourge of the South, pellagra, has been conquered by a proper appreciation of its origin in dietary deficiencies and the development of low-priced dietary auxiliaries to supply those deficiencies.

For the Department of Commerce, the Bureau of Standards displayed a flask of "heavy water," containing an excess of hydrogen isotope 2, which is denser than ordinary water by as much as 180 parts in a million. The Bureau also showed a method of demonstrating the effect of traces of base metal impurities upon the appearance of mercury, by producing large bubbles, 1 or 2 cm. in diameter, through a mixture of mercury and dilute nitric acid. Flakes of rock salt showing plastic deformation, and recently determined spectra of rare elements completed the exhibit.

The Coast and Geodetic Survey displayed a new type of accelerometer, which operates and records vibration for predetermined ranges of vibration.

The Bureau of Fisheries showed samples of fish flour, fish meal, and fish oil, canned oysters and canned salmon, with charts demonstrating their nutritional value, especially newly developed data on their vitamin contents, and the usefulness of oysters in combating nutritional anemia.

The Smithsonian Institution exhibit was by the division of Radiation and Organisms. It consisted of apparatus developed for the measurement of photosynthesis as a function of wave length and intensity of light and carbon dioxide concentration; special light sources and filters; and illustrations of the photochemical and lethal reactions of algae under various wavelengths.

The U. S. National Zoological Park had an exhibit of the Surinam toad, which is rarely seen in zoological gardens.

The Carnegie Institution of Washington displayed results of the research work of several of its departments during the past year, especially the new measurement of the velocity of light conducted at Mt. Wilson, and photographs of the Mercado from Chichen Itzá.

Mr. Bittinger, a well-known Washington artist, showed paintings of several types of spectra, some of them made with pigments of a new type specially made for accurate color representation.

Mr. Clark and Miss Forbes displayed an unrecorded manuscript map of the prehistoric Indian earthworks near the confluence of the Muskingum

and Ohio rivers, drawn by Henry Livingston, Jr., in 1788. It appears to have been the prototype of several later maps of the same region.

The resignation of Dr. CHARLES F. ROOS, permanent secretary of the American Association for the Advancement of Science, has been announced. Dr. Roos will be succeeded by Dr. HENRY B. WARD of the University of Illinois, who will take office in the late spring.

Damage by Fire at Catholic University.—A fire of undetermined origin broke out in the upper part of MacMahon Hall at the Catholic University of America early in the morning of January 6 and wrought severe damage to the botanical laboratory. A preliminary estimate of the total losses is set at approximately $25,000. The greatest harm was the destruction of a collection of plants from the region of San Antonio, Texas, valued at about $1,000, and the burning of a set of taxonomic charts made by the late Dr. Theodor Holm, which are of course irreplaceable. Severe damage was also done by smoke to the botanical library.

Minimum temperatures on Mt. McKinley.—The U. S. Weather Bureau has just tested the historic minimum thermometer that the late Archdeacon HUDSON STUCK cached at a place 15,000 feet above sea level on the slope of Mount McKinley, Alaska, in the summer of 1913, and that was recovered last May by another climbing party. The instrument was brought to Washington for testing by Mr. HARRY J. LIEK, superintendent of Mount McKinley National Park, one of the men who found it. The tests showed it to be an excellent instrument.

When the thermometer was found last spring, the index was not only considerably below the lowest graduation of the scale (93°F. below zero) but was projecting into the bulb in such a position that it could go no farther. Apparently this position denotes the occurrence of a minimum temperature, some time during the 19 years the thermometer lay on the mountain, of at least 100° below zero, and perhaps several degrees lower. The evidence furnished by the thermometer for this remarkably low temperature is by no means conclusive, as the index may have been jarred out of its correct position by wind, and there are other possible conditions that may have affected the correct action of the instrument during its long sojourn on the mountain. But on the other hand, it is thought that a temperature of 100° below zero or lower is not impossible at an altitude of 15,000 feet on this subarctic mountain.

Radio Talks.—W. L. MCATEE, of the Biological Survey, urged the "Preservation of Wild Life along the Potomac" in a radio talk broadcast in the program of the Rod and Stream Department of the Washington *Evening Star* on December 1. "No more useful or interesting task," he concluded, "beckons local members of the Izaak Walton League, and of the Audubon Society, and like organizations, than constantly to urge that all

of the Potomac River that is to be bordered by park projects be made a wild life refuge, to see further that the essential natural features of this great reservation are preserved, and finally, to be on guard at all times against their despoliation."

On December 23, Dr W. B. Bell, of the Biological Survey, spoke over the radio on reindeer in Alaska. Under the auspices of Science Service, the talk was broadcast from Station WJSV and 56 associated stations of the Columbia Broadcasting System.

News Briefs

The Department of Agriculture has recently transferred to the National Museum the large Venturi herbarium, containing about 16,000 specimens representative of slightly more than 10,000 members. The material was collected chiefly in the provinces of Tucuman and Salta, in north-central Argentina, and had been assembled by the late Prof. S. Venturi over a period of about 15 years.

An inaugural banquet of the Smith-Reed-Russell Society of the School of Medicine, The George Washington University, was held at the University Club on the evening of January 13. Guest speakers included Dr. Theobald Smith and Dr. Frederick F. Russell, two of the three scientists in honor of whom the society is named. Other speakers included the President of the University, Cloyd H. Marvin and Colonel Albert E. Truby, who received the key of the society for Walter Reed to transmit to Colonel Walter L. Reed, surviving son.

"Western American Alpines," a new book by Ira N. Gabrielson, the Biological Survey's supervisor of predatory-animal and rodent control in the Pacific Region, has been published by The Macmillan Company.

The Washington Section of the Society of American Foresters met at the Cosmos Club on Thursday, January 12. James W. Girard, Senior Logging Engineer, spoke on "The Forest Survey of the U. S. Forest Service."

Personal Items

Mr. E. C. Crittenden, Chief of the Electrical Division of the Bureau of Standards, sailed on January 13 to attend the third biennial meeting of the Advisory Committee on Electricity and Photometry established by the International Committee on Weights and Measures. The meeting begins on January 31 at the International Bureau of Weights and Measures, at Sevres, just outside of Paris.

Mr. Earl Hanson, observer of the Department of Terrestrial Magnetism, who has been making magnetic observations at repeat stations in various South American countries since August, 1931, having completed his field work was en route for New York early in January. After a brief vacation in

that city, he will report at Washington for comparing his instruments and closing up his work.

Paul E. Howe, chemist, in charge of nutritional work, Bureau of Animal Industry was elected president of the Chemical Society of Washington at its annual meeting. James F. Couch, specialist in toxicology at the same bureau, was selected as one of its managers for the ensuing year. Other officers elected were: James H. Hibben, secretary; Orville E. May, treasurer; H. T. Herrick, H. G. Knight, E. W. Washburn, E. Wichers, R. E. Bigson and M. X. Sullivan, councilors; and J. A. Ambler, N. Beekedal, R. E. Gilchrist, A. T. McPherson and A. R. Merz, managers.

Obituary

Professor Harlan Wilbur Fisk, magnetician and chief of the Section of Land Magnetic Survey, Department of Terrestrial Magnetism, Carnegie Institution of Washington, died at the Washington Sanitarium, Takoma Park, Maryland, on December 26, 1932, after a brief illness. Professor Fisk was born at Geneva, Kansas, September 25, 1869, and was educated at Carleton College, Northfield, Minn. From 1899–1906 he held the professorship of mathematics at Fargo College (North Dakota) and was dean of the faculty from 1904–1906. In October 1906 he joined the staff of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington as magnetic observer. He made two detailed magnetic surveys of the Bermuda Islands in 1907 and 1922, respectively, and led a magnetic-survey expedition to British, Dutch, and French Guiana in 1908. He also took part in various expeditions sent out by the Department to investigate possible effects on the Earth's magnetism due to solar eclipses, the most recent of these being the total solar eclipse of last August when he was in charge of the three parties sent to New England by the Department for this purpose. During the last few years he has been engaged in important researches on the secular variation of the Earth's magnetism based largely on data obtained under his supervision by observers of the Department of Terrestrial Magnetism. Professor Fisk was a member of a number of scientific bodies including the Washington Academy of Sciences, and the Philosophical Society of Washington. He was also an active member of the American Geophysical Union being secretary of its Section of Terrestrial Magnetism and Electricity for the period 1929–1932.

Ernest Howe, geologist and editor of the American Journal of Science, died suddenly Dec. 18, 1932, at his home in Litchfield, Conn. He was born in New York City Sept. 28, 1875, and graduated from Yale University in 1898. From Harvard he received the degree of Ph.D. in 1901. He was a member of the U. S. Geological Survey from 1898 to 1908, and in 1906 and 1907 he was the geologist of the Isthmian Canal Commission. Between 1908

and 1926 he spent much of his time as a consulting geologist in the Grass Valley gold field of California. From 1926 until his death he has edited the American Journal of Science. Among Dr. Howe's best-known publications are his reports on the gold deposits of Grass Valley, California, and the landslides of the San Juan Mountains of Colorado.

Dr. Theodor Holm, research professor of botany at the Catholic University of America, died suddenly on December 26. Dr. Holm was born at Copenhagen, February 3, 1854, and was educated at the University in his native city and graduated in 1880. He was made botanist and zoologist of the Danish North Pole Expedition and spent the next two winters in the ice packs of the Arctic Ocean. He spent the summers of 1884–1886 in West Greenland as botanist and zoologist for the Danish Government. In 1888 he came to the United States and five years later was a naturalized citizen. He explored the high alpine flora of Colorado from 1896 to 1899, and for eight years was botanical assistant at the Smithsonian Institution and the Department of Agriculture at Washington, D.C. Dr. Holm was the author of many papers on taxonomy, morphology and anatomy, medicinal plants and arctic plants. At the time of his death he was working on morphological problems, and his researches were being published as they were completed in the *Botanisches Centralblatt.*

ANNOUNCEMENTS OF MEETINGS

The Academy announces a meeting on February 16. *Program:* L. H. Adams.—*The basic concept of the physical sciences* (illustrated). This is the address of the retiring president.

The Philosophical Society announces the following programs:

February 25. Professor F. D. Murnaghan (Johns Hopkins University.—*The expanding universe.*

March 11. The third Joseph Henry Lecture. President K. T. Compton (Massachusetts Institute of Technology).—*High voltage.*

ADVANCE SUMMARIES

Hereafter the Journal will accept for publication, in addition to original articles and proceedings, short summaries presenting the results of completed research projects. By these advance summaries, prepared by the investigators, the Journal hopes to make current, in advance of final and full publication, the findings of local scientists. These summaries will take the form of regular articles but preferably should not exceed one page in length.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the tenth of each month.

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This Journal, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The Journal is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors before the tenth of one month will ordinarily appear, on request from the author, in the issue of the Journal for the following month.

Manuscripts may be sent to any member of the Board of Editors: they should be clearly typewritten and in suitable form for printing without essential changes. The editors cannot undertake to do more than correct obvious minor errors. References should appear only as footnotes and should include year of publication. To facilitate the work of both the editors and printers it is suggested that footnotes be numbered serially and submitted on a separate manuscript page.

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JOURNAL

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VOL. 23 MARCH 15, 1933 No. 3

PHYSICS:—*Some improvements in psychrometry.*[1] DONALD B. BROOKS and HEMAN H. ALLEN, Bureau of Standards. (Communicated by HUGH L. DRYDEN.)

MODIFIED PSYCHROMETER

Some modifications in psychrometry which may be of interest to meteorologists have been developed in the course of other research work at the Bureau of Standards. The research in question involved the continuous measurement of humidity under conditions considered rather extreme for the ventilated psychrometer, as can be appreciated from the fact that relative humidities lower than 5 per cent at dry bulb temperatures of nearly 150°F were included in the measurements.

An investigation of the conventional ventilated psychrometer under such conditions showed that it did not correctly indicate the humidity, when the Ferrel formula[2] was used. The psychrometric constant required to give a correct value of the humidity increased with an increase either in temperature or in wet-bulb depression. Experiment indicated that this occurred because the temperature of the water in the wet-bulb supply tube was materially above the wet-bulb temperature. Consequently, if sufficient water were supplied to the wick to keep it wet, the water, not being cooled sufficiently by evaporation before reaching the bulb, raised the temperature above evaporation temperature.

Increasing the length of exposed wick between the supply tube and the bulb did not correct this condition, as the resultant diminished water supply to the wet bulb was not adequate to maintain wetness under conditions causing wet-bulb depressions of over 60 Fahrenheit degrees.

[1] Received November 26, 1932.
[2] Report of Chief Signal Officer, U.S.A., 1886. p. 249.

It was obvious that better, if not satisfactory, results could be obtained by maintaining the water supply at or near wet-bulb temperature. This was accomplished automatically in both of the two modified types of psychrometer which are shown in Figures 1 and 2. In both of these instruments the air supply is passed over the dry and wet-bulb thermometers as in other ventilated psychrometers. In the instrument shown in Figure 1, the air which has passed the thermometers is passed over the wet-bulb water-supply tube, which is electroplated with silver, perforated by a number of small holes, and surrounded with a wick, thus constituting an auxiliary wet bulb. In this apparatus this auxiliary wet bulb is in the wake of the thermometric wet bulb. The apparatus shown in Figure 2 is similar, except that both the thermometer wet bulb and the auxiliary wet bulb are cooled by the air the humidity of which is to be determined. The instrument illustrated in Figure 1 is adapted to conditions where the volume of air to be handled is small, while that illustrated in Figure 2 may be used where the volume is large.

Since the auxiliary wet bulb, in the first case mentioned, is in the wake of the thermometric wet bulb, it cannot attain as low a temperature as the latter. In practice, however, the temperature of the wet-bulb water supply was within one or two Fahrenheit degrees of the temperature of the thermometric wet bulb. This difference caused no difficulty, as was indicated by the invariance of the psychrometric constant. In the second case, both the thermometric and the auxiliary wet bulbs are cooled by air of the same humidity, and the water supplied was cooled practically to evaporation temperature before reaching the thermometer wick.

TABLE 1.—CONSTANT A_0, OF MODIFIED PSYCHROMETER

No. Runs	No. Obs.	Equivalent Altitude ft.	Dry Bulb °C	Rel. Hum. per cent	A_0	Comparison
11	53	Sea Level	Over 60	*ca.* 7	0.000642	Psychrometer[a]
1	1	" "	56.8	0.6	0.000656	"
7	7	" "	*ca.* 20	Over 80	0.000638	"
1	8	12,500	*ca.* 27	*ca.* 30	0.000646	"
1	14	28,000[b]	*ca.* 25	*ca.* 20	0.000663	"
1	2	30,000[b]	*ca.* 21	*ca.* 25	0.000678	"
58	217	Sea Level	21 to 64	0.6 to 64	0.000648	"
14	53	" "	21 to 65	5 to 63	0.000650	Chem. Analysis

[a] Checked against a comparison psychrometer, the latter operating under favorable conditions. See Appendix.

[b] Subject to rather large errors because pulsation in air stream rendered air pressure measurements uncertain. Exhaust pump operating at capacity. Note that only 2 observations were taken at 30,000 ft.

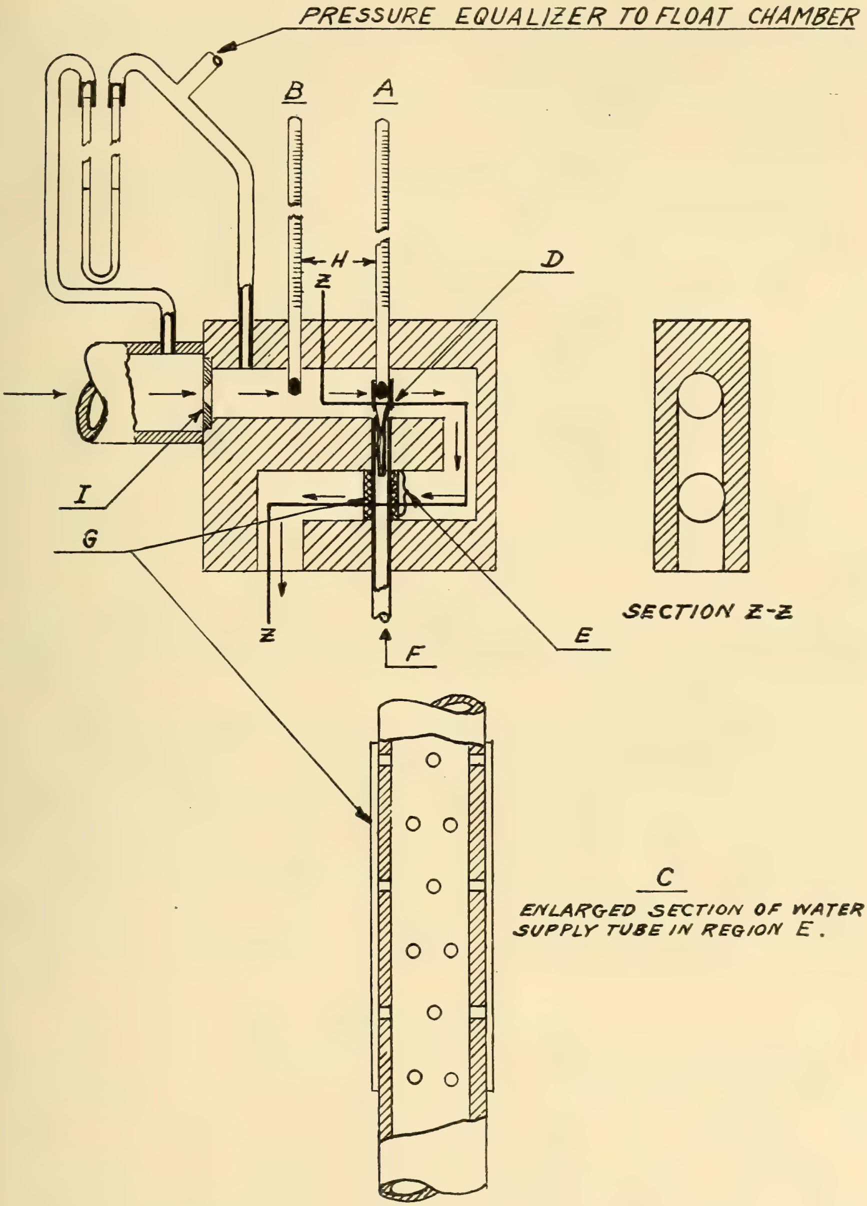


Figure 1.—Psychrometer No. 1. *A*—Wet-bulb thermometer; *B*—Dry-bulb thermometer; *C*—Enlarged section of water supply tube (*F*) in region (*E*); *D*—Wick for wet-bulb thermometer; *G*—Auxiliary wet bulb; *H*—Minimum distance between thermometers; *I*—Orifice.

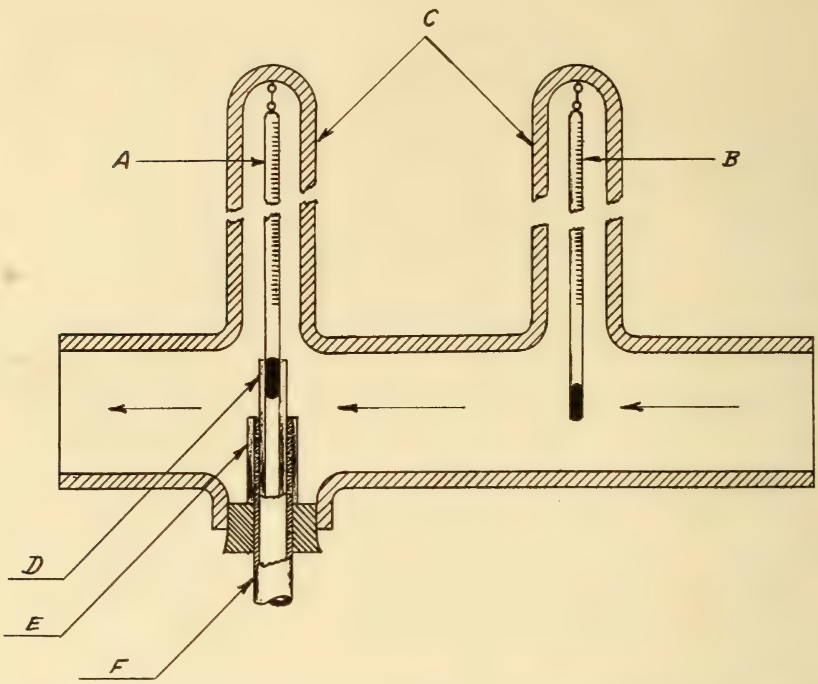


Figure 2.—Psychrometer No. 2. *A*—Wet-bulb thermometer; *B*—Dry-bulb thermometer; *C*—Thermal shields; *D*—Wick for wet-bulb thermometer; *E*—Auxiliary wick; *F*—Water supply tube.

The results of tests summarized in Table 1 were obtained by the use of a set-up which permitted the variation of temperature, humidity, and air pressure (altitude). The methods used in evaluating the psychrometric constant A_0 are discussed hereinafter. It can be seen from the values of A_0 given in Table 1 that this quantity is essentially a constant for the modified psychrometer, over a rather wide range of temperature, relative humidity, and air pressure or altitude.

TESTS AT "ALTITUDE"

One point possibly of interest to meteorologists was noted during the "altitude" runs. Before making tests to evaluate A_0 under any set of conditions, runs were made to determine the requisite ventilation. Figure 3 is a plot of the results of tests at sea level and at 29,500 ft. equivalent altitude, in which the values of the psychrometric constant, corrected to 0°C, are plotted against the ventilation, expressed as average air speed past the instrument in cm. per second. It is apparent that the requisite speed is higher at the lower air pressure. The relation of the two is made obvious when the constant is plotted

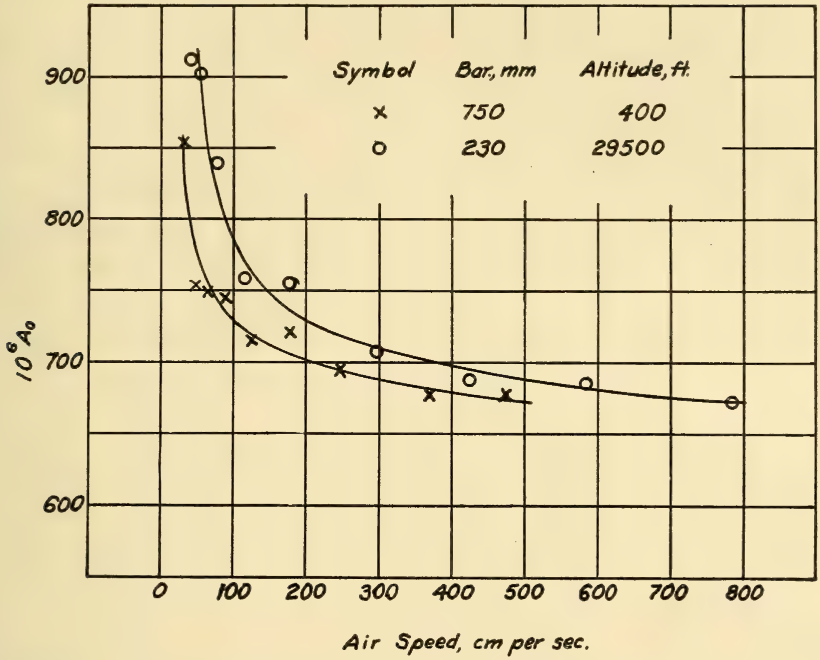


Figure 3.—Variation of coefficient "A_0" with average air speed, at sea level and at 29,500 feet.

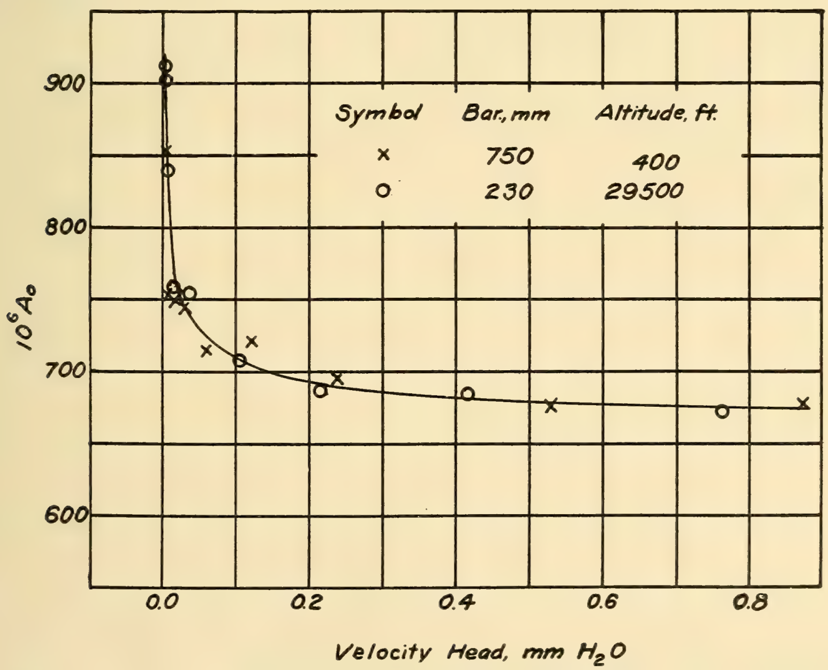


Figure 4.—Variation of coefficient "A_0" with air velocity head, at sea level and at 29,500 feet.

against ventilation expressed as velocity head in terms of a fluid of constant density, as in Figure 4. The velocity head is here defined as $\frac{1}{2}\rho v^2$, where ρ is the air density and v is the average air speed. Tests at various altitudes agree in demonstrating that the air speed for adequate ventilation varies inversely as the square root of the air pressure. Thus, if a certain psychrometer requires 3 meters per second ventilation at sea level, it will require 4 meters per second at 15,000 ft., 5 meters per second at 25,000 ft., and 6 meters per second at 32,000 ft. While this would be of little or no consequence if the psychrometer had ample ventilation, the accuracy of one having barely adequate ventilation at sea level might be impaired at even moderate altitudes.

SUB-FREEZING TESTS

As a matter of interest, tests were run also in which the evaporation temperature was below zero. By operating at reduced air pressure, the wet bulb depression was increased to a point such that residual errors of temperature measurement had little effect on the results.

Three types of "wet bulb" were studied in this work: (*a*) supercooled water supplied as at normal temperatures; (*b*) ice frozen on a wick; and (*c*) ice formed as a coat on the bare thermometer bulb.

When operating with supercooled water at temperatures from $-2°C$ to $-6°C$, no definite variation of the psychrometer constant was observed in the course of 30 tests. However, the value of the constant was about 0.00069; furthermore, the top of the wick appeared to be insufficiently wet. This did not occur when operating above or near zero.

Tests were made with ice formed on a wick, either (1) by immersion in distilled water at zero, and subsequent freezing, or (2) by operating the psychrometer so as to maintain the wet bulb above zero until the wick was saturated, then so altering conditions as to induce freezing.[3] By method (1) the constant was about the same as with supercooled water (See Figure 5, solid circle); by method (2) it was somewhat variable and higher than by method (1).

In the ice-coated wet-bulb experiments, ice films of thickness up to about one millimeter were used. A film of 0.5 mm. thickness was noted to have about as rapid response to fluctuations in humidity as the ordinary wick-covered wet-bulb. Figure 5 shows the results of tests to determine ventilation requirements with ice bulbs. The solid line is the mean characteristic for wick-covered wet bulbs; the broken

[3] At times this was not possible. With water super-cooled to $-5°C$, mechanical agitation of the wick frequently failed to cause freezing.

line represents the same values multiplied by the ratio of the latent heat of evaporation of water to that of ice. From this figure it appears that the ventilation requirement for ice-covered bulbs varies with altitude in the same manner as that of ordinary wet bulbs; further, there appears to be no material difference in the ventilation requirement of ice bulbs and wet bulbs. However, ice-coated bulbs cool more slowly. The effect of this is to make the time lag somewhat greater

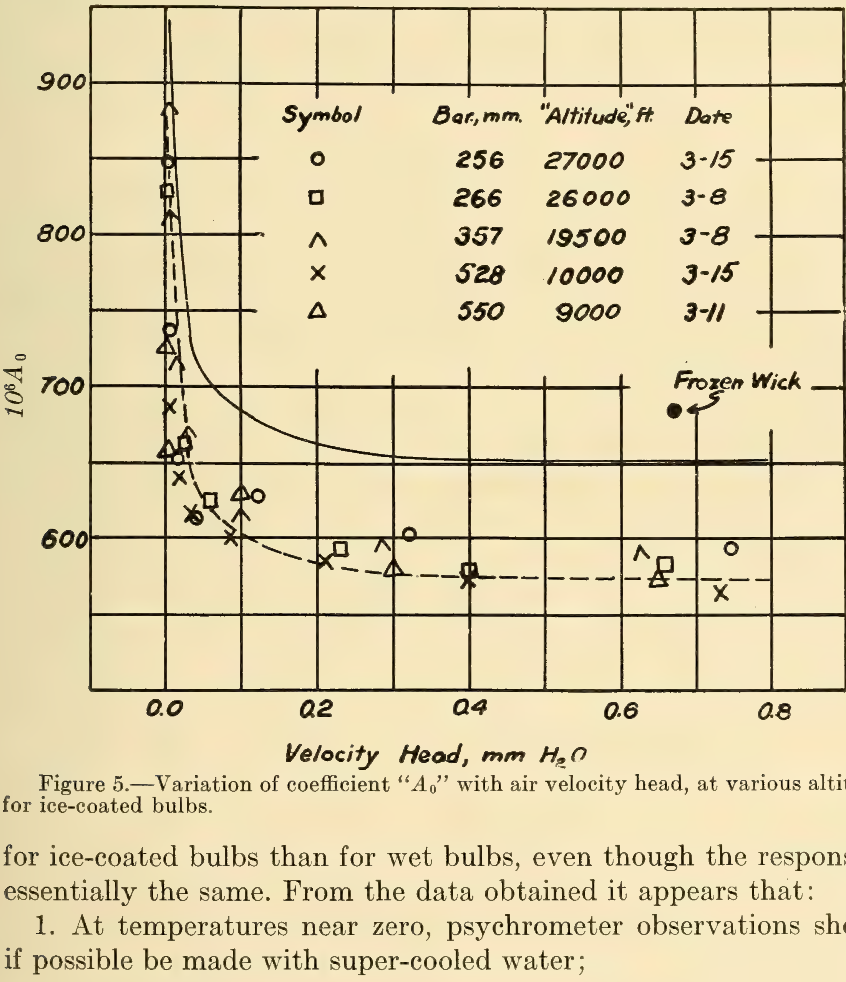


Figure 5.—Variation of coefficient "A_0" with air velocity head, at various altitudes for ice-coated bulbs.

for ice-coated bulbs than for wet bulbs, even though the response is essentially the same. From the data obtained it appears that:

1. At temperatures near zero, psychrometer observations should if possible be made with super-cooled water;

2. At lower temperatures, more exact results can be obtained by discarding the wet-bulb wick, replacing it with a thin film of ice, and reducing the constant in proportion to the ratio of the latent heat of evaporation of water to that of ice, which is 0.882.

3. The ventilation velocity required will be the same in this case

as with the ordinary wet bulb; the time required to reach evaporation temperature will be roughly four times that with the wet bulb.

4. If a frozen wick is used, the constant required is the same as that for water. This fact may be ascribed to two factors, tending to produce opposite effects, approximately equal in amount, namely, the lower value of the constant required with ice, and the partial drying of the wick, in the time required to reach equilibrium.

5. An ice film of 0.5 mm. thickness is approximately as sensitive as a wick covered wet bulb; such a film exposed to an air stream of 5 meters per second will last roughly one hour, with a saturation deficit of approximately 3 mm. mercury.

A NEW PSYCHROMETRIC CHART

Humidity ordinarily is found from the dry and wet-bulb temperatures by double interpolation in a table listing pressure of water vapor, dew point, or relative humidity at a definite barometric pressure; then, if accuracy is desired, a correction, obtained from a second table is applied for the difference between the tabular and the observed barometric pressures.

A much simpler method of obtaining humidity is afforded by use of the chart, Figure 6. The accuracy with which the vapor pressure can be estimated from this chart when reproduced to a size of 8 by 10 inches is about 0.005 in mercury or better, which is sufficient for ordinary purposes.

To use this chart, place a straightedge so that it intersects the extreme left scale at the value of the difference between wet- and dry-bulb temperatures, and intersects the wet-bulb scale at the value of wet-bulb temperature. Extend this line to its intersection with the vertical line representing the barometric pressure, and read the corrected pressure of water vapor on the scale at the extreme right.

To determine the relative humidity, transfer the value of the pressure of water vapor thus obtained to the same value on the heavy vertical line representing standard barometric pressure. Connect by a straight line the point so obtained and the point representing the value of the dry bulb temperature on the diagonal line marked "Dry Bulb." Extend this line to its intersection with the vertical line on the left, and read the relative humidity on the inner left scale.

In obtaining the pressure of water vapor when the wet-bulb temperature is below freezing, the "Wet Bulb" scale is employed if the psychrometer was used with either supercooled water or a frozen wick. However, if the evaporation temperature was obtained with an

ice-coated thermometer, the "Ice Bulb" scale, to the right of the "Wet Bulb" scale, must be used.

The precision and time saving resulting from use of the chart instead of computations from the psychrometric formula or estimation from the Psychrometric Tables[4] was found from a series of timed computations, and is shown in the following tabulation:

	Formula	Tables	Chart
Average deviation from computed humidity value, in. Hg	—	0.0036	0.0021
Average deviation from computed values of relative humidity, per cent	—	0.40	0.36
Relative time required for estimation	6	2	1

It will be seen that estimations from the chart are at least as precise as are determinations from the tables, and are twice as rapid. This information was obtained using a preliminary chart, not as precise as is Figure 6. Estimation of humidity from a chart, 16 by 20 inches in size, should not appreciably impair the precision even of results obtained by use of the modified psychrometers described herein.

The method of constructing this type of chart is described elsewhere,[5] except for the scales of relative humidity and dry bulb temperature. The "Dry Bulb" scale lies on a line connecting zero relative humidity with zero pressure of water vapor; the point on this line corresponding to a given temperature is located by passing a line through 100 per cent relative humidity and through the saturation pressure (scale at right) corresponding to the temperature in question. The point required lies at the intersection of this line with the dry bulb scale. This operation should be done analytically rather than graphically.

METHODS USED IN CALIBRATING PSYCHROMETERS

Calibration of a psychrometer by comparison with humidity values obtained by absorption methods, while precise if done by an expert technician, is laborious. Calibrations by comparison with another psychrometer, drawing air from the same source, may be made readily and rapidly, and under proper conditions are accurate.

Three methods of calibration by comparison with another psychrometer have been utilized in this work. In no case is it necessary to compute the actual humidity of the air supply. All methods are based on the applicability of the general psychrometric formula, and

[4] W. B. No. 235, 1912.
[5] Bureau of Standards Jour. of Research, Nov. 1929. 795.

on the premise that both psychrometers draw air from the same source.[6]

The first of these methods, which was developed for the study of the modified psychrometer at high temperatures and low humidities,

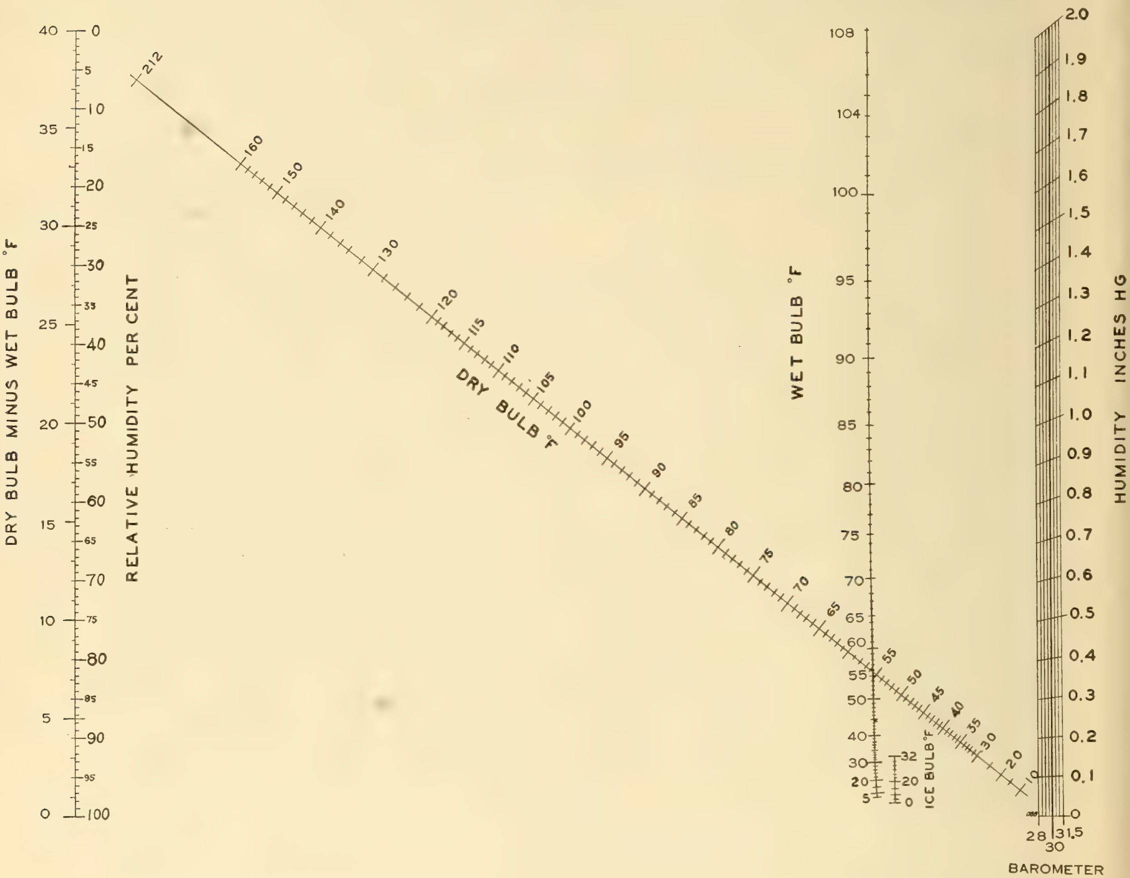


Figure 6.—Chart for estimation of pressure of water vapor and relative humidity from psychrometric observations.

consists in comparing its readings with those of another psychrometer, the latter drawing air from the same source but at a temperature(or pressure) in the range known to allow accurate measurement of humidity. Even when the humidity is not accurately determined, it can be shown mathematically that the constant found for the test psychrometer will be but little affected thereby.

The second method was developed for study of the modified psychrometer at reduced air pressures, simulating altitude operation.

[6] See appendix for theory involved in these methods.

One of the two identical psychrometers was operated at sea-level pressure (hence under known conditions) and the other at reduced pressures. As a study of the results by means of the first method (above) showed no marked deviation of the constants of the two instruments from the theoretical value, a mean value of the constant will be obtained by assuming the constants of the two psychrometers to be identical. The mean constant was thus obtained without the necessity of assuming a value of the constant for either instrument. This method is applicable to operation at different temperatures as well as at different pressures.

TABLE 2.—DETERMINATION OF PSYCHROMETER CONSTANT

	Comparison Psychrometer		Test Psychrometer	
Run No.	1	2	1	2
Barometer, mm. Hg	748.6	748.3	485.5	748.3
Dry Bulb, °C	4.80	4.79	5.65	4.54
Wet Bulb, °C	−0.63 (water)	−0.60	−3.12 (ice)	−1.14
Constant, 3rd Method	0.000653		0.000570	
Theoretical constant	0.000652		0.000575	
Constant, 1st Method	(Assumed 0.000652)		0.000570	0.000569

If, as in the case of the ice-bulb tests, there is a theoretical reason why the constants should not be equal for the two instruments, the second method, above, is not applicable. To meet this case, and to obviate the necessity inherent in the first method, for assuming the value of the constant of the comparison psychrometer, a third method was developed. This method requires readings on both psychrometers under not less than two sets of conditions. The more diverse the conditions are for either psychrometer, the more precise is the value of the constant obtained for it. By this method, the constant is separately obtained for each psychrometer, the sole assumption being that each constant, corrected for variation of latent heat of evaporation with temperature, is the same under the two sets of conditions.

The following example serves to illustrate the use of this method. In one of the "ice-bulb" tests, the comparison psychrometer was operated at sea-level pressure, using supercooled water, while the test psychrometer, operated first at reduced pressure, then at sea-level, had an ice-coated thermometer serving as the "wet bulb." The observations and results are given in Table 2.

Table 3 gives an idea as to the relative precision to be expected of each of the comparison methods described above, under representative conditions.

From this table it is apparent that, even if it be assumed that no error is involved in the chemical measurement of humidity the probable error of the psychrometric constant as determined by these comparison methods is such as to recommend their use, in view of the much greater rapidity with which determinations can be made.

TABLE 3.—COMPARISON OF METHODS FOR EVALUATING THE PSYCHROMETRIC CONSTANT

GENERAL ASSUMPTIONS

Air to test psychrometer at 30°C except Method D, Case 2; pressure of water vapor 1 per cent of total pressure. The probable error of the psychrometric constant is given as millionths of a unit per hundredth of a degree probable error in temperature measurements.

Method	Specific Assumptions	Error of $A(\times 10^6)$
A—Chemical comparison	Chemical error zero	1
B—Psychrometric comparison	Comparison psychrometer air at 10°C; its constant assumed $(660 \pm 30) \times 10^{-6}$	1.4
C—Psychrometric comparison	Constants assumed equal. Test psychrometer at 380 mm. Hg. pressure, comparison psychrometer at 760	3.3
D—Psychrometric comparison	No assumptions regarding constants. Case 1. One set of runs with test psychrometer at 760 mm. Hg., comparison at 380; second set with pressures reversed	5.8
	Case 2. One set, one dry bulb 30°C, other 60°C; second set temperatures reversed.	0.74

APPENDIX

CALIBRATION OF PSYCHROMETERS BY INTERCOMPARISON

The general psychrometric formula is

$$E = E' - A_0 B(T - T')(1 + CT') \qquad (1)$$

where

E = pressure of water vapor
E' = vapor pressure of water (saturation pressure) at temperature T'
B = barometric pressure
T = air temperature
T' = evaporation temperature
A_0 = psychometric constant at 0°C
C = factor dependent on variation of latent heat of evaporation with temperature.

In the subsequent equations, capital letters refer to the comparison, or standard psychrometer, and lower case letters, having the same meanings, to the test psychrometer. Since both draw air from the same source,

$$\frac{E}{B} = \frac{e}{b}. \tag{2}$$

From equations (1) and (2) the formulae for the three comparison methods are derived.

First Method

Value of A_0 assumed; value of a_0 required

From (1) and its counterpart

$$e = e' - a_0 b(t - t')(1 + ct') \tag{3}$$

and from equation (2) above,

$$a_0 = \frac{Be' - bE' + A_0 Bb(T - T')(1 + CT')}{Bb(t - t')(1 + ct')}. \tag{4}$$

Formula (4) enables evaluation of the test psychrometer constant.

Second Method

a_0 assumed equal to A_0

From equations (1), (2) and (3), and the above assumption,

$$a_0 = A_0 = \frac{Be' - bE'}{Bb[(t - t')(1 + ct') - (T - T')(1 + CT')]}. \tag{5}$$

If, as is the case when both wet bulbs are using water, $c = C$, formula (5) may be simplified accordingly.

Third Method

A_0 and a_0 to be evaluated

To simplify the equations, let

$$x = (T - T')(1 + CT')$$
$$y = (t - t')(1 + ct')$$
$$z = \frac{Be' - bE'}{Bb}$$

and let the subscripts 1 and 2 denote the values for the successive sets of conditions under which each psychrometer is operated.

Then from formulae (1) and (2)

$$\begin{aligned} A_0 x_1 - a_0 y_1 &= z_1 \\ A_0 x_2 - a_0 y_2 &= z_2 \end{aligned} \tag{6}$$

and

$$\begin{aligned} A_0 &= \frac{y_1 z_2 - y_2 z_1}{x_2 y_1 - x_1 y_2} \\ a_0 &= \frac{x_1 z_2 - x_2 z_1}{x_2 y_1 - x_1 y_2}. \end{aligned} \tag{7}$$

If more than two observations on each psychrometer are to be included, the general equation

$$A_0 x - a_0 y = z \tag{8}$$

is solved for the psychrometric constants. Using the method of Least Squares

$$A_0 = \frac{\Sigma y^2 \Sigma xz - \Sigma xy \Sigma yz}{\Sigma x^2 \Sigma y^2 - (\Sigma xy)^2}$$
$$a_0 = \frac{\Sigma xy \Sigma xz - \Sigma x^2 \Sigma yz}{\Sigma x^2 \Sigma y^2 - (\Sigma xy)^2}. \quad (9)$$

BOTANY.—*New grasses from Kashmir.*[1] A. S. HITCHCOCK, Bureau of Plant Industry.

Recently there was received for identification, from Dr. E. D. Merrill, Director of the New York Botanical Garden, a package of grasses collected in Kashmir, by Walter Koelz, for the Urusvati Himalayan Research Institute, Roerich Museum, Naggar (Punjab), India. The specimens were transmitted to Dr. Merrill by Dr. R. R. Stewart, Professor of Biology in Gordon College, Rawalpindi, India. Among them were two undescribed species, one of which represents a new genus.

The new genus belongs to the tribe Chlorideae, and is allied, though not closely, to *Leptochloa* and to *Trichoneura*. The type species was collected at an altitude of 15,500 feet, which fact suggested the generic name (from one of the Greek words meaning a mountain dweller), and was found growing on sand dunes, which fact suggested the specific name.

The other species belongs to a genus of which only two species, both Asiatic, were previously known. The original, or type species, was described a few years ago by the Russian botanist Roshevitz (*Timouria saposhnikowi* Roshev.) from a specimen collected in the Tian-Shan, Turkestan. A few years later I proposed a new genus of grasses based upon a species (*Psammochloa mongolica* Hitchc.), from Mongolia. Soon after the publication of this genus I discovered that it was the same as *Timouria* of Roshevitz (his publication having been inaccessible because of the World War) but was based upon a different species.[2] Now a third species comes to our attention from Kashmir. The genus *Timouria* is allied to *Oryzopsis*.

Timouria aurita Hitchc., sp. nov.

Perennis, glauca; rhizomata repentia; culmi erecti, scaberuli, 60 cm. alti, nodis glabris; vaginae retrorso-scaberulae, inferioribus albidis; ligula membranacea, ciliata, 1 mm. longa; laminae erectae, involutae, scabrae, 10–30 cm. longae, 1–3 mm. latae, apice pungente; panicula angusta, pallens vel

[1] Received November 8, 1932.
[2] For a discussion of this subject see This JOURNAL **17**: 140. 1927, and **18**: 502. 1928.

purpurascens, circa 10 cm. longa, ramis appressis, inferioribus inferne nudis; spiculae brevipedicellatae, pedicellis scabris; glumae membranaceae, acutae, scaberulae, 7 mm. longae; lemma villosum, glumis paulo brevius, apice bidentato, dentibus setiformibus, 3–4 mm. longis; arista curvata, persistens, 1 cm. longa.

Fig. 1.—*Timouria aurita.* Glumes and floret ×5 dia.; summit of lemma ×10 dia.

Fig. 2.—*Orinus arenicola.* Upper part of panicle, natural size; spikelet ×5 dia.

Perennial, with slender hard scaly rhizomes; foliage glaucous, the lower part of the plant pale or whitish; culms erect, scaberulous, about 60 cm. tall, the nodes glabrous; sheaths retrorsely scaberulous; ligule membranaceous, lacerate and ciliate, 1 mm. long or less; blades erect, scabrous, flat or mostly involute, 10 to 30 cm. long, 1 to 3 mm. wide, attenuate to a fine sharp whitish point; basal prophylli prominent, 5 to 10 cm. long, sharp-pointed; panicle narrow, pale or purplish, 10 cm. long, the branches appressed, the lower somewhat remote, naked below, these and the short pedicels scabrous; glumes nearly equal, rather broad, membranaceous, 3-nerved, acute, scaberulous, about 7 mm. long; lemma a little shorter than the glumes, densely long-villous, 3-nerved, bidentate, the teeth setiform, 3 to 4 mm. long; awn from between the teeth of the lemma, somewhat curved, not twisted, persistent, scaberulous, about 1 cm. long.

Type in U. S. National Herbarium, no. 1535770, collected in sand at Kugzil, Rupshu, Kashmir, Western Himalayas, India, alt. about 4300 meters, July 16, 1931, by Walter Koelz (no. 2328).

This species differs from the others in the setiform teeth of the lemma and in the more persistent awn.

Orinus Hitchc., gen. nov.

Spiculae pauciflorae, secus rhachin continuam breviter pedicellatae; rachilla teres, glabra, supra glumas et inter flores articulata; glumae membranaceae, acutae, paulum inaequales; lemmata prominente 3-nervia, villosa, obtusiuscula, mutica, apice integro. Gramen perenne, rhizomatibus repentibus; racemi secus axem erectum adscendentes; culmi caespitosi, erecti; laminae planae vel involutae. (ὀρεινός, a mountaineer.)

Spikelets few-flowered, short-pediceled in one row along one side of a continuous rachis, appressed, the rachilla disarticulating above the glumes and between the florets, the flowers perfect; glumes membranaceous, acute, slightly unequal; lemmas prominently 3-nerved, villous, awnless, the obtusish apex entire. Perennial, with creeping rhizomes; panicle of several racemes along an elongate erect axis; culms cespitose, erect; blades flat, becoming involute.

Type species, *Orinus arenicola.*

This genus differs from *Leptochloa* Sect. Diplachne, and from *Trichoneura*, in the entire awnless apex of the lemmas and in the villous pubescence evenly distributed over the lemma instead of confined to the nerves.

Orinus arenicola Hitchc., sp. nov.

Culmi glabri, 30–50 cm. alti; vaginae villosae vel glabrescentes; ligula 1 mm. longa; laminae 1–3 mm. latae, apice pungente; panicula 5–15 cm. longa; racemi 5–8, recti, 1–7 cm. longi; spiculae 2–3-florae; glumae 4–5 mm. longae; lemmata 3.5–4 mm. longa.

Culms cespitose, firm, erect, slender, glabrous, 30 to 50 cm. tall, from hard scaly creeping rhizomes; sheaths rather densely to sparsely villous, the lower glabrous, yellow; ligule about 1 mm. long, thin, lacerate; blades flat, becoming involute, sparsely pilose, 3 to 10 cm. long, 2 to 5 mm. wide, the apex sharp and finally hard; panicle 5 to 15 cm. long, with 5 to 8 erect or ascending racemes 1 to 7 cm. long, the lower naked at base; spikelets pale or leaden-purplish tinged, about 6 mm. long, 2 to 3-flowered, rarely 4-flowered, the rachilla slender, glabrous, the internode between the first and second floret about 1 mm. long; glumes pale, 4 to 5 mm. long, sparsely villous to nearly glabrous, acute, the first 1-nerved, the second 3-nerved; lemmas dark, often spotted, 4.5 to 5 mm. long, keeled, somewhat concave between the nerves, the obtusish tip hyaline; palea about as long as the lemma, villous; stamens 3, the anthers 3 mm. long; stigmas 2, plumose.

Type in the U. S. National Herbarium, no. 1535771, collected in bare sand, at Tsaka, Ladak, Kashmir, Western Himalayas, India, alt. 4700 meters, July 18, 1931, by Walter Koelz (no. 2365).

BOTANY.—*A new grass from Texas.*[1] AGNES CHASE, Bureau of Plant Industry.

Within the last year four previously unknown grasses were discovered in Texas. Recently another, not closely related to any other North American species, was sent to the Grass Herbarium by Mr. J. F. Combs, county agricultural agent, Beaumont, Texas. This grass has been found in three places only, all in Jefferson County, eastern Texas. Besides these new species several grasses not previously known from the United States have been found in Texas.

Paspalum almum Chase

Planta perennis caespitosa; culmi compressi, simplices, 30–50 cm. alti; vaginae carinatae glabrae; laminae 5–17 cm. longae, 2–3 mm. latae, basi hirsutae; racemi 2–3, approximati, 5–9 cm. longi; rhachis 1 mm. lata; spiculae solitariae, 3 mm. longae, 1.8–2 mm. latae, glabrae; gluma 5-nervis; lemma 5-nerve.

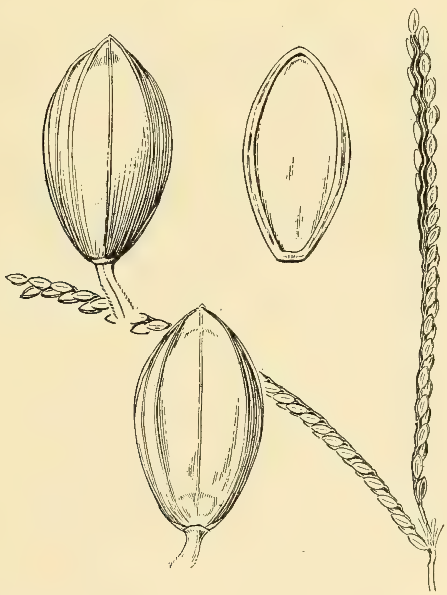


Fig. 1.—*Paspalum almum.* Inflorescence, natural size; two views of spikelet and one of fruit × 10 dia.

A densely tufted perennial; culms ascending to spreading, simple, 30 to 50 cm. tall, flattened, glabrous; leaves crowded toward the base; sheaths keeled, glabrous, the lower overlapping; ligule pale, membranaceous, about 1.5 mm. long; blades flat, rather firm, 5 to 17 cm. long (the uppermost reduced), 2 to 3 mm. wide, long-hirsute on the upper surface at base, papillose-

[1] Received November 8, 1932.

hirsute on the lower surface toward the ends, usually with a few hairs on the upper surface, the margins stiffly ciliate toward base; racemes commonly 2, sometimes 3, approximate (the common axis 5 to 20 mm. long), ascending, often somewhat recurved, 5 to 9 cm. long; rachis flexuous, 1 mm. wide, with a narrow winged margin, glabrous, the margin and midvein above scabrous; spikelets on minute flat pedicels, solitary, scarcely imbricate, 3 mm. long, 1.8 to 2 mm. wide, obovate-elliptic, glabrous; glume and sterile lemma equal, 5-nerved, the lemma slightly concave and sometimes faintly fluted; fruit slightly smaller than the spikelet, smooth and shining.

Type U. S. National Herbarium no. 1,535,768, collected on fine sandy and silty clay loam, near Beaumont, Jefferson County, Texas, September 8, 1932 by J. F. Combs.

This very distinct species belongs in the Notata group but is not closely allied to any of its five North American species.

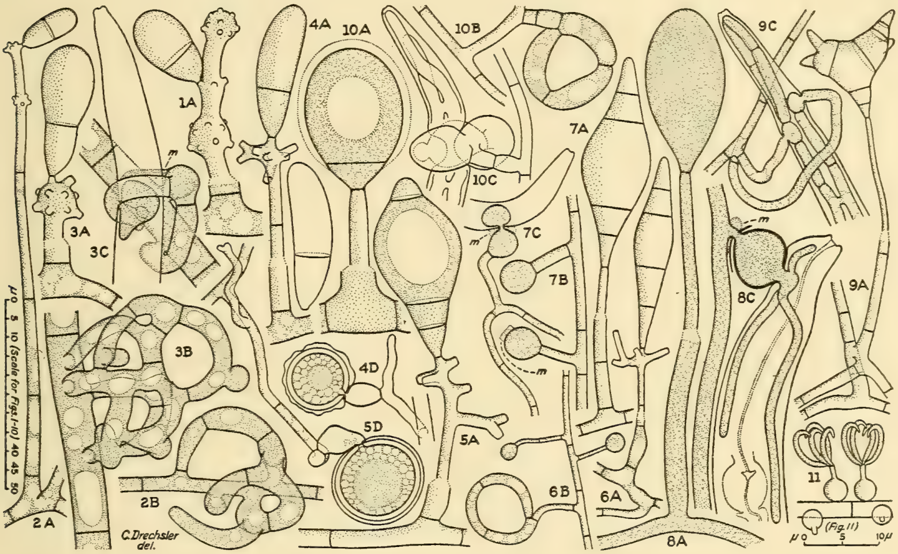
Mr. Combs writes that the species is found only on the Lake Charles soils, derived from sedimentary deposits in the Coastal Plain, and that it is an excellent forage grass, hence the specific name, *almum*, nourishing.

BOTANY.—*Morphological diversity among fungi capturing and destroying nematodes.*[1] CHARLES DRECHSLER, Bureau of Plant Industry.

Nematodes mostly of the genera *Rhabditis* and *Diplogaster* infesting agar plate cultures prepared from plantings of diseased rootlets or other decaying plant materials have been found destroyed often in such enormous numbers that the numerous heaped masses of their remains became visible to the naked eye as scabby superficial deposits. Among these fungi the one (Fig. 1, A) discussed by Zopf[2] as *Arthrobotrys oligospora* Fres. was often encountered. Three species evidently closely related to it and similarly having 1-septate conidia—one (Fig. 2, A) with the markedly smaller spores divided into somewhat less unequal cells and borne usually in one or two whorls on minute sterigmata; another (Fig. 3, A) bearing longer conidia with characteristically tapering basal cells, usually in a single terminal whorl likewise on sterigmata distributed over a recognizable enlargement; and a third (Fig. 4, A) with straight or slightly curved elongated ellipsoidal conidia borne in looser capitate arrangement on a terminal head of stubby branches—showed close similarity to *A. oligospora* also in manner of capture and killing. The animal was caught in one or more of the anastomosing hyphal loops (Figs. 2, B; 3, B) produced abundantly on the surface of the substratum by all

[1] Received February 10, 1933.
[2] Nova Acta K. Leop.-Carol. Deut. Acad. Naturf. 52: 314–341. 1888.

these fungi and coated on their inner surfaces at least in large part with a transparent highly adhesive substance. Soon its integument was narrowly perforated by one or several processes arising usually from the inner face of the loop, and its internal structure fatally disrupted by the rapid intrusion of one or several inflated parts often very largely and sometimes completely occupying the body section involved (Fig. 3, C). Likewise in a species (Fig. 5, A) with 3-septate, obovoid spores borne in loose capitate arrangement on short subapical



Figs. 1–10.—Various nema-capturing fungi, each numeral denoting a separate species, and all species drawn with the aid of the camera lucida at the same magnification; ×500. A, Conidiophore (shown completely only in Fig. 2) with attached conidium of approximately average size, shape and condition with respect to septation. B, Organs of capture, either adhesive hyphal loops or adhesive knob-cells. C, Internal disruptive development of fungus, or its external constrictive swelling, Figs. 3, 7 and 8 showing condition at the time the animal's movements ceased. D, Intramatrical resting reproductive structures. *m*, Adhesive mucous substance. Fig. 11.—Portion of fertile branch of *Harposporium anguillulae*, ×1000.

branches as well as on the apex, large loops often in extensive anastomosing systems are formed, and the same mode of capture, penetration and internal disruption of the animal prevails. In a species (Fig. 6, A) with narrower, 4-septate, spindle-shaped conidia borne similarly in terminal, somewhat loose, branching capitate arrangement, the rather small loops are supplemented by globose cells borne on delicate lateral hyphal branches (Fig. 6, B). These cells, like the homologous but more robust structures (Fig. 7, B) of a closely related species (Fig. 7, A) that produces mostly solitary, 4-septate, broader, spindle-

shaped conidia, capture their prey by means of a strongly adhesive substance which becomes visible as a transparent disc-shaped cushion surrounding the point of contact with the struggling animal (Fig. 7, C). Penetration of the integument and production of an expanded part within ensues as in the case of the loops. It was undoubtedly such adhesive globose cells that Zopf interpreted, in excusable error, as conidia of his *Monosporidium repens*. Capture by adhesion, associated, however, with the formation by the fungus of a strongly inflated, thick-walled, yellow distension mostly outside the animal though with a smaller distal lobe protruding within (Fig. 8, C), is prevalent in a fungus having a large, non-septate, obovoid spore borne singly at the apex of a non-septate sporophore, the latter arising from a non-septate mycelium suggesting the mycelium of species of *Pythium* in the appearance of its protoplasmic contents (Fig. 8, A). Adhesion on hyphal tips, accompanied with rather little differentiation of vegetative parts both outside and inside of the animal (Fig. 9, C), appears to be effective in the somewhat more feebly predacious activity of a fungus bearing solitary spores, inverse pyramidal, distally twice bifurcate, usually 4 to 7 septate,—two transverse septa regularly occurring in the narrowing proximal part, two oblique ones regularly delimiting laterally a third or central cell, the remaining partitions being variously disposed in the divergent lobes (Fig. 9, A). A fungus (Fig. 10, A) bearing a large, solitary, obovoid, 1-septate conidium, the disproportionately large distal cell of which latter is often encased in a mucous coating, captures its prey in mostly intramatrical, vertically oriented hyphal loops (Fig. 10, B), killing it however, not by protrusion of a bulbous outgrowth within the animal's body, but by constriction effected through pronounced swelling of the three loop-cells, the swelling taking place more especially toward the center of the loop (Fig. 10, C).

In addition to the aerial colorless conidia that readily become detached from the rather tall (.1 to .5 mm.) colorless conidiophores present in all the nema-capturing fungi discussed, several species have been found to produce within the substratum yellow resting reproductive structures, usually terminally on single somewhat inflated cells,—the whole arrangements of parts, with the sometimes loosely enveloping outer membrane, curiously suggesting sexual apparatus of certain oomycetes. The seven fungi first referred to, which have been isolated, show in pure culture a correspondence in vegetative and sporulating habits that indicates a much closer natural relationship than distribution among such genera as *Arthrobotrys*, *Cephalo-*

thecium, Trichothecium, Dactylaria, and *Dactylella* might seem to imply.

The non-predacious parasite described in detail by Zopf as *Harposporium anguillulae* Lohde was also often found highly destructive to nemas in many agar cultures. In undisturbed and well developed material four of the crescentic spores were rather regularly seen attached to the tip of the slender cylindrical outgrowth arising from the spherical part sessile on the fertile branch, thus plausibly characterizing the flask-shaped structure as a basidium, and the fungus as a basidiomycete (Fig. 11).

ZOOLOGY.—*A bivulvar specimen of the nematode* Mononchus muscorum *(Dujardin) Bastian.*[1] GERTRUDE HENDERSON CASSIDY, Hawaiian Sugar Planters' Association. (Communicated by G. STEINER.)

Mononchus muscorum (Dujardin) Bastian 1865[2] is a species of wide geographical distribution; in 1930 specimens were found for the first time on the island of Maui, Territory of Hawaii.[3]

During that year considerable numbers of *Mononchus* had been collected from the islands of Oahu, Hawaii, Maui, and Kauai, and specimens of twelve species identified. For the most part observations had been restricted to the lower lying cultivated areas bearing sugar cane and pineapples, but later it was considered advisable to include some of the more remote forest lands and unfrequented mountainous ridges with a view to determining the possible indigenous nematode population of the Hawaiian Islands.

For this reason nemic collections were made at known elevations on the slopes of Haleakala, the highest mountain on the island of Maui. The ascent was made under the direction of the forest ranger and a route selected which is seldom if ever frequented save by an occasional pheasant hunter or by the inspecting forester.

The various collections present a wide range of nematode genera including several species of predacious mononchs,—among them the specimen of *M. muscorum* depicted which was found in loose cindery soil surrounding dandelion roots growing on the east side of the crater at an elevation of 8,000 feet. At this elevation practically all vegetative growth had ceased and only stunted grasses and occasional weeds

[1] Received October 13, 1932.

[2] BASTIAN, H. C. *Monograph on the Anguillulidae.* Trans. Linn. Soc. London. **25**: 103. 1865.

[3] CASSIDY, G. *Some Mononchs of Hawaii.* Hawaii. Planters' Rec. **35**: 330. 1931.

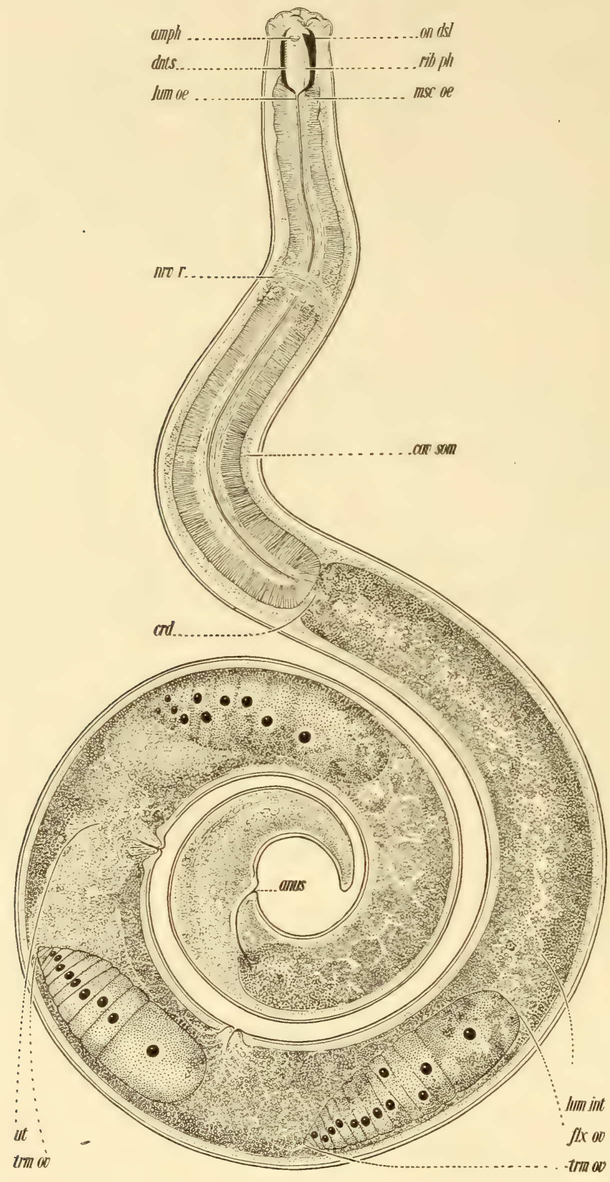


Fig. 1. Bivulvar *Mononchus muscorum: amph*, amphid; *anus*, anus; *cav som*, somatic cavity; *crd*, cardia; *dnts*, pharyngeal teeth; *flx ov*, flexure of ovary; *lum int*, lumen of intestine; *lum oe*, lumen of oesophagus; *msc oe*, musculature of oesophagus; *nrv r*, nerve ring; *on dsl*, dorsal onchium; *rib ph*, pharyngeal rib; *trm ov*, terminus of ovary; *ut*, uterus. × about 200.

were to be found in the coarse cindery deposit of the upper volcanic ridges.

This specimen of *M. muscorum* immediately attracted attention by reason of the abnormality of the reproductive organs. Two well developed vulvar openings are clearly defined: one situated at 55 per cent of the total body length, and the other at 66 per cent. (See Fig. 1.) Three reflexed ovarian tubes are present: one, on the left side, lying anterior to the proximal vulva; the other two situated anterior (left side) and posterior (right side) to the distal vulva. The distal vulva is regarded as more nearly approaching the normal by reason of the slightly better development of the supporting muscles, by its position (normal specimens commonly show the vulvar aperture at about 64 per cent) and because of the paired ovarian tubes and uteri connected with it.

The percentage measurements of this specimen are as follows:

2.7	9.0	23.5	${}^{15}\cdot 55.0$	${}^{15}\cdot 66.0^{16}\cdot$	91.0	1.7 mm.
3.0	—	4.0	5.0	5.0	3.0	

The percentage measurements of a normal specimen obtained from the same collection are as follows:

2.7	9.0	23.5	${}^{16}\cdot 64.0^{16}\cdot$	91.0	2.0 mm.
3.0	—	4.0	5.0	3.0	

This is the fourth case of bivulvarity yet recorded from free-living nemas. The first was mentioned by Bütschli[4] for a marine nematode *Linhomoeus mirabilis* Bütschli; the second by Paramonov[5] for the freshwater species *Trilobus gracilis* Bastian, and the third by the present writer[6] for a Dorylaimus species. Undoubtedly all these cases must be considered abnormal or even pathological. The one here described is the most pronounced because it concerns not only a duplication of vulva and vagina, as in the instances mentioned by Bütschli, Paramonov, and Cassidy, but the duplication includes also uterus and ovary.

From the description and figure given by Bütschli, it is assumed that only the anlage of vulva and vagina was doubled and this at a rather late stage of development, judging from the close position of the duplicates.

[4] Bütschli, O. *Zur Kenntniss der freilebenden Nematoden, insbesondere der des Kieler Hafens.* Abhandl. d. Senckenb. naturf. Gesell. Frankfurt a.M. **9**: 33. 1874.

[5] Paramonov, A. *Über einen Fall von "Bivulvarität" bei einem freilebenden Nematoden.* Russ. Hydrobiol. Ztschr. **5**: 218–222. 1926.

[6] Cassidy, G. *A meristic variation in a female nematode.* Nature **121**: 476–477. 1928.

The same was apparently true for *Trilobus gracilis* described by Paramonov, but here the duplicates are more distant, suggesting a somewhat earlier separation.

In the bivulvar Dorylaimus previously recorded by the present writer there were two vulvae 0.062 mm. apart, each with a vagina, a uterus, and an ovary. This suggests that a separation of the paired anlage of the anterior and the posterior branch of the female apparatus took place, since normally these dorylaims are amphidelphic.

In the *Mononchus* here described the duplication involves the whole anterior branch of the normal female apparatus suggesting a separation of its anlage at a very early date of its development, but still at a time when the anlage for the normal female apparatus would have already divided into its anterior and posterior branch.

The causes for these duplications are unknown. It is remarkable that they all concern female specimens and that up to the present no such duplications have been observed in male nematodes.

ZOOLOGY.—*Two new species of Isopod Crustaceans from California.*[1] J. O. MALONEY, U. S. National Museum. (Communicated by WALDO L. SCHMITT.)

In the course of his studies on littoral ecology at Monterey Bay, California Coast, Dr. G. E. MacGinitie of the Hopkins Marine Station obtained, among other crustaceans, two species of isopods of the family Idotheidae which seem never to have been described, *Synidotea macginitiei* and *Pentidotea montereyensis*. The description of each is based on a male holotype preserved in alcohol.

A specimen from San Francisco Bay, however, has been taken as the type of *S. macginitiei*, as Dr. MacGinitie's specimens were small and with adult characters not fully developed. The specimens from San Francisco Bay were identified by earlier workers as *Synidotea laticauda*,[2] though they are more closely related to *Synidotea bicuspida* (Owen).[3]

Synidotea macginitiei, new species

Description.—Body ovate, length 15 mm., width 7.25 mm. (third and fourth thoracic segments widest). Head 2.5 mm. long, 3.25 mm. wide, with

[1] Published by permission of the Secretary of the Smithsonian Institution. Received November 30, 1932.

[2] BENEDICT, JAMES E. *A revision of the genus* Synidotea. Proc. Acad. Nat. Sci. Philadelphia, 1897. 389–404. *figs. 1–13.*

[3] RICHARDSON, H. *Monograph on the Isopods of North America.* U.S.N.M. Bull. **54:** pp. i–liii, 1–727. *figs. 1–740.* 1905.

front produced on either side of a median excavation in a narrow border, the lateral portions of which form an angle with the dorsal portion as in *S. bicuspida*. Eyes not visible in a ventral view, small, round, and situated on either side some distance from lateral margin which is expanded to form a narrow border. First and second articles of first antenna about equal in length; third, one and one-half times length of second; fourth a little shorter than third. First pair of antennae extend to middle of fourth peduncular joint of second pair. Basal and second articles of second antenna about equal in length, basal article not visible in dorsal view; third and fourth each about twice as long as second; fifth nearly as long as third and fourth together. Flagellum consists of fifteen articles. terminal one tipped with a tuft of hairs. Second antenna extends to posterior margin of third thoracic segment. Ventral side of left outer lobe of first maxilla consists of eleven tooth-like spines, many of them denticulate, and one long tapering spine. Some of the long plumose hairs of outer lobe of second maxilla extend to second joint of second antenna. (See Fig. 1.)

Fig. 1.—*Synidotea macginitiei*, new species. *a*, right second maxilla. *b*, left maxilliped; *c*, left first maxilla, outer lobe. *d*, left first maxilla, inner lobe.

The first segment of the thorax, measured on the median dorsal line, is the shortest, following segments subequal. Lateral margins of segments almost straight.

Abdomen triangular in shape, length 6.75 mm., with median notch at apex of terminal segment. Telson is similar to that of *S. bicuspida*, and is as wide at base as it is long. The legs are similar in shape; propodus, carpus, and merus thickly beset with hairs on inner margin.

Color in alcohol a yellowish-brown with irregular markings of dark brown. These markings prominent on head and longitudinal median portion of

body. Sides of head below eyes and epimera with many small splotches of dark brown.

Holotype.—A male, U.S.N.M. Cat. No. 66413 taken by the *Albatross* in San Francisco Bay, California has been selected as the type. Dr. MacGinitie collected six specimens at Monterey Bay, of which the largest is 9.5 mm. long. The species is named for him, as it was his material which first called my attention to this new species.

Remarks.—This species is close to *S. bicuspida*, the more noticeable differences being in the head and mouth parts. The frontal margin is more nearly straight and the eyes more laterally situated in *S. bicuspida* than in *S. macginitiei.* A prominent lateral margin below the eyes is absent in *S. bicuspida.* The epipod of the maxilliped, the outer lobe and relative length of its plumose hairs of first maxilla, and the teeth and denticulations of outer lobe of second maxilla are different in the two species.

Pentidotea montereyensis, new species

Description.—Body elongate, length 25 mm., width 3.75 mm., length of abdomen 8 mm.; sides of thorax nearly parallel. Head wider than long, 4.5 mm. long, 3.25 mm. wide; frontal margin excavate, antero-lateral angles rounded. Eyes moderately large, on lateral margin of head about half way between anterior and posterior margins. First article of first antenna dilated, three following articles subequal, terminal article clavate. First antenna extends to distal end of second peduncular joint of second antenna. First article of peduncle of second antenna very short, not visible from above; next two articles equal in length and each a trifle shorter than either of the two following, which are also equal in length; flagellum consisting of about sixteen articles. The second antenna extends to middle of third thoracic segment. The outer lobe of first maxilla has eleven tooth-like spines, several of which are denticulate, and a long hair-like spine in the center. On ventral surface there is a large setule in a cup-shaped articular cavity.

First and seventh segments of thorax equal in length, and a little shorter than the others which are subequal. Epimera on second to fifth segments do not extend entire lateral margin. (See Fig. 2.)

Abdomen consists of three segments, two of which are small; terminal segment long, with lateral indications of a partially coalesced segment. Telson convex and slightly excavate on lateral margins; posterior portion broadly rounded with a small median point.

Legs similar in structure; propodus beset with hairs on inner margin.

Holotype.—A male, U.S.N.M. Cat. No. 66414, one of three specimens collected by Dr. McGinitie at Monterey Bay.

Remarks.—This species stands near *Pentidotea aculeata* Stafford,[4] differing mainly in the shape of thoracic segments, their epimera, and median notch of telson. The lateral margins of the first three thoracic segments of *P. aculeata* are more angulate, while those of *P. montereyensis* are almost straight; the median notch in *P. aculeata* is much longer; and all the epimera of *P. aculeata* extend to posterior margin, while in *P. montereyensis* only the last two epimera do so.

[4] Stafford, B. E. *Studies in Laguna Beach Isopoda.* Jour. Ent. Zool. Claremont. Cal. **5**: 182–188. *figs. 6–10.* 1913.

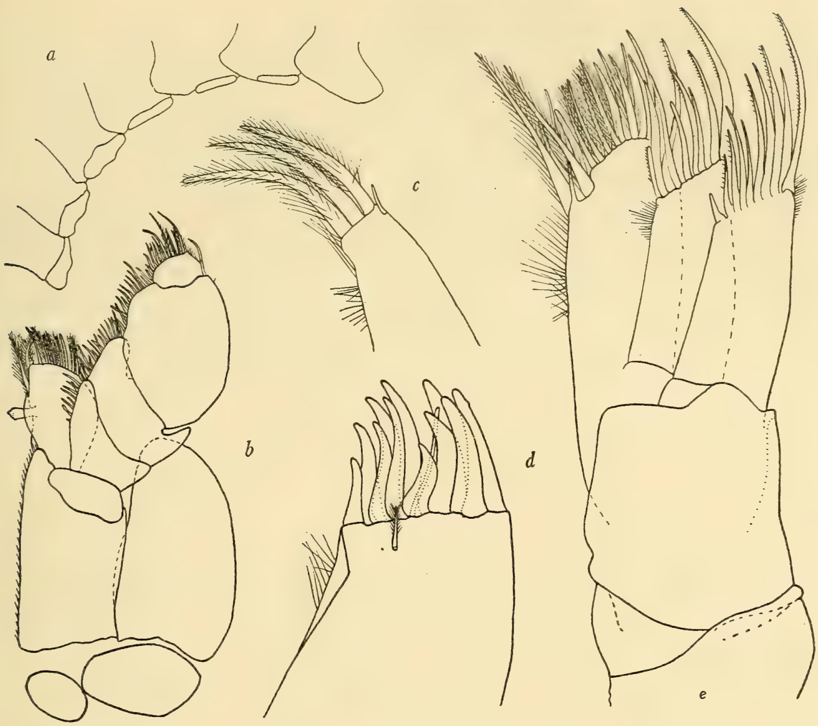


Fig. 2.—*Pentidotea montereyensis,* new species, *a,* right lateral side of thorax showing epimera. *b,* left maxilliped. *c,* left first maxilla, inner lobe. *d,* left first maxilla, outer lobe. *e,* left second maxilla.

ENTOMOLOGY.—*A new parasite of* Laspeyresia molesta *Busck.*[1]

T. Uchida, Hokkaido Imperial University, Sapporo, Japan. (Communicated by Harold Morrison.)

Laspeyresia molesta Busck, a very destructive pest of pears and apples, each year causes great losses to fruit culture in Japan. It is, therefore, necessary to investigate the control of this pest. I have to date found only one species of the family Ichneumonidae, *Ephialtes laspeyresiae* Uchida, parasitic on *L. molesta.* But R. A. Cushman, of the United States Bureau of Entomology, has just sent me specimens of a second species reared from this host in Japan. This beneficial insect appears to me to be new to science, and I describe it below.

My best thanks are hereby extended to R. A. Cushman, who sent me this valuable material.

[1] Received November 7, 1932.

Dioctes molestae, new species

Female.—Head with fine, white pubescence, somewhat narrowed posteriorly; frons and face finely coriaceous punctate, opaque; clypeus not separated from face; mandibles stout, teeth equal. Antennae filiform, somewhat more than half as long as body. Thorax opaque, densely, finely punctate and pubescent like the head; mesopleurum with nearly opaque speculum; scutellum flat; areolation of propodeum distinct, costulae strong, area superomedia open behind, area basalis very narrow. Tibial spurs somewhat shorter than metatarsus; claws sparsely pectinate. Abdomen weakly compressed toward apex; postpetiole longer than broad, nearly smooth, weakly shining, second segment distinctly longer than broad, a little impressed at base, third quadrate, the others broader than long. Ovipositor weakly curved upward, half as long as abdomen. Wings hyaline; disco-cubitus curved in middle.

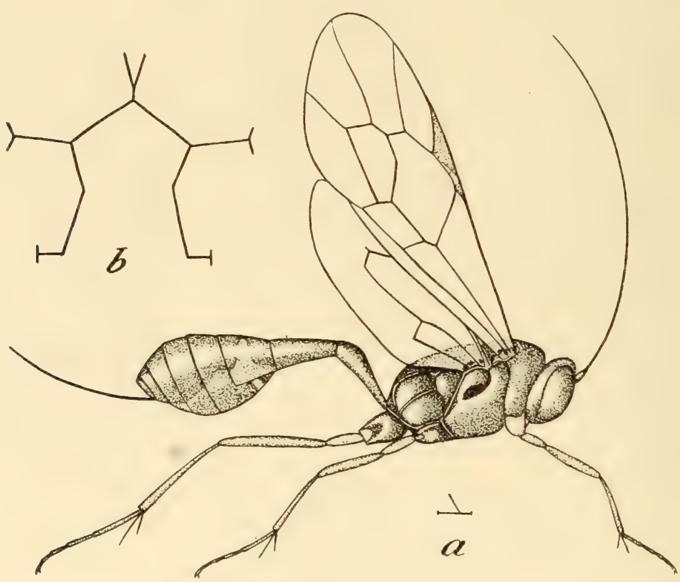


Fig. 1. *Dioctes molestae* n.sp. *a.* Lateral view. *b.* Areolation of propodium.

Length.—5–6 mm.; antennae 4 mm.; ovipositor 2 mm.

Black and opaque. Antennae brownish black to black; scape and pedicel yellowish brown below. Mandibles except apex, palpi, front and middle coxae, all trochanters and ventral plica of abdomen whitish yellow; legs ferruginous, hind coxae, middle coxae, and hind trochanter basally, black; hind tibia and tarsus apically brownish. Abdominal segments 2–4 more or less dark brown, especially at sides. Stigma dark brown.

Male.—Unknown.

Type-locality.—Japan.

This species is related to the European species, *D. crataegellae* Thoms., from which it differs in the color of the abdomen and in the length of the ovipositor.

ARCHAEOLOGY.—*Hopewell type pottery from Louisiana.*[1] F. M. SETZLER, U. S. National Museum. (Communicated by JOHN R. SWANTON.)

Owing to the fact that up to the present time only two vessels have been found south of the Ohio River[2] which are recognized as belonging to the Hopewell culture in the Upper Mississippi Valley,[3] it seems highly important to bring to the attention of archeologists a general description of the pottery vessels and other artifacts discovered in the east central part of Louisiana, near Marksville.

The pottery and associated artifacts herein described were excavated by Gerard Fowke during his explorations in the Red River Valley of Louisiana, February–May, 1926. No illustrations or description of the specimens appear in his final report[4] though in the preliminary report[5] a few were reproduced.

Analysing the restored vessels from Mounds 4 and 8 in the Marksville Works, we find the following variations of and resemblances to the Hopewell pottery: (Fig. 1) One vessel may be considered typically Hopewell because of such features as the cross-hatched band and bisected cones just beneath the rim. The decoration on the body of the vessel consists of smooth bands outlined by incised grooves. The area outside the bands is roughened uniformly by means of the roulette, and a conventionalized eagle is outlined on each of the four lobes. (Fig. 2.)

We also find two flat bottom bowls decorated on the inside and outside of the rim with triangular notches. A constriction near the middle of each cone-shaped vessel divides the decoration into two distinct parts. The figures on the lower half have been outlined by incised grooves forming conventionalized birds, the head of each suggesting the eagle. The area outside the smooth bands has been roughened by means of the roulette. The motif on the upper half is again outlined by incised grooves and consists of heart and pear-shaped

[1] Published by permission of the U. S. National Museum, Smithsonian Institution. Received October 28, 1932.

[2] MOORE, C. B. Jour. Acad. Nat. Sci. Phila. **13**: 286–88. *figs. 3, 4, and 5.* 1908.

[3] For a detailed description of Hopewell characteristics, see: MILLS, W. C., and SHETRONE, H. C. *Exploration of Hopewell Group.* Certain Mounds and Village Sites in Ohio. **4**: pt. 4, 297–305. 1926; SHETRONE, H. C. *Culture Problems in Ohio Archaeology.* Amer. Anthropologist. n. ser. **22**: No. 2, 144–172. 1920; SHETRONE, H. C. and GREENMAN, E. F. *Exploration of the Seip Group of Prehistoric Earthworks.* Ohio Archaeol. and Hist. Quart. **40**: No. 3, 343–509. 1931.

[4] FOWKE, G. *Archaeological Investigations.* 44th Ann. Rep., Bureau of American Ethnology, Pt. 2, 405–434. 1928.

[5] FOWKE, G. *Archaeological Work in Louisiana.* Smithsonian Misc. Coll. **78**: No. 7, 254–59. 1926.

objects and meandering or curvilinear bands which have been polished. The rest of the area is uniformly roughened by means of the roulette.

On a fourth vessel the manner of outlining by deeply incised grooves and the zigzag roughening bears resemblance to the aforementioned

Fig. 1. Hopewell vessel, probably from Mound 2 of the Mound City Group near Chillicothe, Ohio. Originally in the collection of Dr. Edwin Hamilton Davis. Reproduction of a drawing from *Sketches of Monuments and Antiques; found in the Mounds, Tombs and Ancient Cities of America*, p. 49, The portfolio of Dr. Davis' collection is in the manuscript room of the Bureau of American Ethnology.

ones. However, the band of decoration below the rim is radically different from the typical Hopewell design, yet it is closely comparable to that on one of the other vessels. This jar also has lightly incised parallel lines running at a forty-five degree angle which probably indicate an incomplete cross-hatched design such as is found on the typical Hopewell jars.

Another vessel too has the characteristic smooth bands outlined

with grooves while the rest of the surface is roughened. Instead of the typical cross-hatch and punctate design below the rim, it has only the line of punctates or bisected cones while the area directly above it, which is usually cross-hatched, is smooth.

Still another vessel has the beginning of what appears to be the

Fig. 2. The most typical Hopewell vessel from the Marksville Works. From Mound 8. Dia. $3\frac{1}{4}$ inches; H. $4\frac{3}{8}$ inches. U. S. Nat. Mus. Cat. No. 331688.

cross-hatched design below the rim, but the area around the neck differs from any design found on the typical northern Hopewell specimens. This consists of a series of three parallel grooves one inch long and a series of nine indentations, three rows of three each, made with a blunt instrument. The fact that this vessel was found associated with the typical Hopewell vessels from Mound 4 would seem to be sufficient evidence that it belongs to the same culture, although it em-

bodies an entirely different method of decoration, i.e., the concentric grooves with narrow polished bands between. The method of decorating vessels with concentric grooves and smooth narrow bands, although it differs radically from the typical Hopewell, was found on one miniature vessel to form two conventionalized eagles. This conventionalized eagle design certainly resembles the designs on the more typical Hopewell vessels from Marksville, as well as on numerous Hopewell objects.[6]

This analysis indicates that all of the vessels from Mounds 4 and 8 of the Marksville Works show a definite relationship to each other and some of them closely resemble vessels from the Hopewell culture in the Upper Mississippi Valley.

Associated with the pottery in Mounds 4 and 8, Mr. Fowke found the following artifacts: Monitor or platform pipe of clay, $3\frac{1}{4}$ inches long, $1\frac{1}{16}$ inches wide and $1\frac{3}{4}$ inches high at the bowl. The diameters of the bowl measured from the outside in each case are $1\frac{1}{16}$ and $1\frac{1}{8}$ inches. Fragmentary base of another platform pipe, $2\frac{1}{2}$ inches long and $\frac{3}{16}$ inch wide. Three projectile points. Sandstone rubbing or smoothing stones. Impressions in clay of a vertically plaited matting, consisting of over-two-under-two technique.[7]

The platform pipes and matting imprints are outstanding characteristics of the Hopewell culture in the north.

A tabulation has been made of the decorated vessels and sherds illustrated and described in various publications[8] dealing with the excavation of mounds in the Upper Mississippi Valley recognized as having been built by Indians possessing Hopewell characteristics.

It seems obvious from such a tabulation that the most outstanding feature of the decoration on the Upper Mississippi Hopewell vessels

[6] For other examples embodying conventionalized eagle designs, see: Mills, W. C. *Exploration of Mound City Group.* Certain Mounds and Village Sites in Ohio. **3**: pt. 4, 354–359. *figs. 60, 61, 62, 63, 64, 65.* 1922.

[7] For similar matting from an Ohio Hopewell mound, see: Mills, W. C. Op. cit., 382. *fig. 81.*

[8] Willoughby, C. C. *Turner Group of Earthworks, Hamilton County, Ohio.* Papers of Peabody Mus. Amer. Archaeol. and Ethn., Harvard Univ. **8**: No. 3. 1922; Moorehead, W. K. *Hopewell Mound of Ohio.* Field Mus. Nat. Hist., Anthrop. Ser. **6**: No. 5, 75–178. 1922; Mills, W. C., and Shetrone, H. C. *Exploration of Hopewell Group.* Certain Mounds and Village Sites in Ohio. **4**: pt. 4, 79–305. 1926; Squier, E. G., and Davis, E. H. *Ancient Monuments of the Mississippi Valley.* Sm. Contrib. to Knowledge. **1**: 187–190. 1848; Mills, W. C. *Exploration of Edwin Harness Mound.* Ohio Archaeol. Hist. Quart. **16**: No. 2, 113–193. 1907; Shetrone, H. C., and Greenman, E. F. *Explorations of the Seip Group of Prehistoric Earthworks.* Ohio Archaeol. Hist. Quart. **40**: No. 3, 343–509. 1931; Mills, W. C. *Exploration of Mound City Group.* Certain Mounds and Village Sites in Ohio. **3**: pt. 4, 245–406. 1922. *Exploration of the Tremper Mound.* Idem **2**: pt. 3, 105–240. 1917. *Exploration of Seip Mound.* Idem **2**: pt. 1, 1–57. 1917; McKern, W. C. *Wisconsin Variant of the Hopewell Culture.* Milwaukee Public Mus. Bull. **10**: No. 2, 185–328. 1931.

and sherds is that surfaces of 31 show bands of various dimensions outlined with deeply incised grooves and the areas between or outside the grooves uniformly roughened either by roulette, zigzag, punctate or cord marks. Nineteen of the illustrations show that the area just below the rim of the jars has been decorated with incised cross-hatched lines and an encircling line of bisected cones. The forms vary, there being 12 bowls, 11 jars, and 2 vases. There are five examples of supporting feet. Seven jars are shaped with four lobes—the predominant style—one with six, and one with three lobes. Twelve have round bases, seven have pointed bases, and five have flat bases. No applied pigment is used for decoration.

With regard to the decoration on the vessels and sherds from Mounds 4 and 8 in the Marksville Works, we find that 9 of the 12 restored vessels have bands outlined by deeply incised grooves, and the bands or the remaining parts of the vessel were uniformly roughened —on three specimens by means of the roulette, three by concentric grooves or bands, two by means of zigzag lines and one by the punctate method. On four of the jars the area just below the rim is decorated with cross-hatched incised lines and the encircling line of bisected cones. Thus far a similarity is obvious. The tempering used in the Marksville pottery differs radically, however, from that common to the northern Mississippi type. In the former, either pulverized potsherds or particles of hard clay are used; in the latter, grit or shell. The bases of all the Marksville vessels, so far as could be determined, were flat. Four of the Marksville vessels are bowls, four vases, three jars and one is unique. Only one is four lobed.

This comparison between the Marksville and the recognized Hopewell wares shows a close similarity and one of the vessels from Marksville is a type identical with northern Hopewell. Independent invention of so complicated a technique of decoration where there is such striking similarity would seem impossible. Further investigations may throw additional interesting light on the distribution of the Hopewell Culture. In Ohio, where the center of this highly developed mound building culture is located, no evidence has been found which enables anthropologists to say to what ethnological or linguistic group these Indians belonged. It would seem from the above facts that Louisiana, Mississippi, and perhaps Arkansas must be considered in the distribution of Hopewell traits. These similarities in the south may be due to commercial intercourse but, nevertheless, they are important.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

248TH MEETING

The 248th meeting of the Academy was held in the Assembly Hall of the Cosmos Club on Thursday, April 7, 1932, President Adams presiding. About 150 persons were present.

Program: Arthur Holmes, Professor of Geology, University of Durham, England: *The thermal history of the earth.*

249TH MEETING

The 249th meeting of the Academy was a joint meeting with the Geological Society of Washington, held in the Assembly Hall of the Cosmos Club, Thursday, November 17, 1932. About 150 persons were present. President Adams called the meeting to order at 8:20 P.M., and introduced Doctor Douglas Johnson, Professor of Physiography, Columbia University, who delivered an illustrated address on *Some problems of the arid landscape.* He discussed the history of land changes as recorded in the erosion surfaces seen in the arid districts. The land forms found were attributed to the eroding power of streams forming fans which were traceable in simple and compound form in widely separated areas of the earth. Several members discussed the paper from the floor.

250TH MEETING

The 250th meeting of the Academy was a joint meeting with the Philosophical Society of Washington, held in the Assembly Hall of the Cosmos Club, on Thursday, December 15, 1932, President L. H. Adams presiding. About 175 persons were present.

Program: Paul R. Heyl, Bureau of Standards: *Romance or Science:*—The elusive and unreal character of modern physical concepts has suggested in certain quarters that perhaps physicists are suffering from the effect of too much learning. It can be shown, however, that the present state of physical theory is the logical result of an evolution whose guiding principle has been that of simplicity and economy of thought, as laid down by Occam and Newton, that no more causes than are sufficient are to be assigned for the explanation of phenomena, a principle regarded for six centuries as the most approved rule of philosophy. If the application of this principle leads us to concepts which appear romantic, perhaps this is because for the first time in the history of human thinking we have come close enough to reality to catch a glimpse of it. (*Author's abstract.*)

Charles Thom, *Recording Secretary*

PHILOSOPHICAL SOCIETY

1041ST MEETING

The 1041st meeting was held in the Cosmos Club Auditorium, Saturday evening, October 8, 1932, President Tuckerman presiding.

Program: C. B. Watts: *The U. S. Naval Observatory Eclipse Expedition to Maine* (illustrated).—The Naval Observatory party was located in Limington, Maine, near the village of Limerick, and was under the direction of Commander C. H. J. Keppler, U.S.N. Photographs of the corona were

made with cameras of various sizes, ranging from one of 65 feet focal length down to a motion-picture camera of 17 inches focal length. While thin clouds cut down the fainter portions of the corona considerably, the large camera gave excellent detail in the inner corona. The times of contact were observed visually and with the motion-picture camera. (*Author's abstract.*)

H. W. Fisk: *Eclipse observations of the Department of Terrestrial Magnetism, Carnegie Institution of Washington* (illustrated).—In accordance with its custom, the Department of Terrestrial Magnetism made use of the occasion of the total solar eclipse of August 31, 1932, to collect additional data bearing upon a possible effect on the magnetic field due to the passage of the Moon's shadow across the Earth.

The observations undertaken on this occasion were very simple, consisting of eye-readings of declination only, using the ordinary field-magnetometer. Three stations were established within the belt of totality, two being about equally distant from the center line in northern Vermont and western Maine, in approximately the same latitude, the third being near the center line, farther south, on the New Hampshire-Maine border.

The days preceding the eclipse were characterized by a moderate magnetic storm, which had nearly disappeared by the day of the eclipse. A comparison of the graphs drawn from the observations at the three stations showed a very close identity of curve for the three field-stations, and these were very similar in detail to the curves taken from the Agincourt and Cheltenham magnetograms. An interesting feature apparent on each of the curves was a small but very distinct fluctuation which occurred immediately after totality at the field-stations and coincided quite exactly with the time the shadow crossed the New England coast-line and passed out over the sea. The occurrence of this small disturbance after many hours of normal diurnal-movement was quite startling and its coincidence with totality was very suggestive of a possible connection, although it is recognized that the coincidence may have been entirely fortuitous.

Previous investigations have led to the conclusion that the eclipse-effect on the magnetic field is that of a dimunition in the expected departure of a value of an element from its daily mean value, and that this takes place somewhat gradually during the entire interval during which the Moon's shadow falls upon the Earth. Superimposed upon this general effect there has been detected another effect corresponding to the local eclipse-interval. However, because of other irregularities which are continually occurring and which are entirely independent of the eclipse, it is only by a discussion of a large mass of data that conclusions may be safely reached. (*Author's abstract.*)

S. S. Kirby and T. R. Gilliland: *The radio eclipse observations of the Bureau of Standards* (illustrated).—Radio observations made in Washington and Nova Scotia by the Bureau of Standards during the solar eclipse of August 31 were described. Professor Chapman in England had suggested that the lower of the two observed ionized regions of the upper atmosphere was caused by bombardment of neutral corpuscles shot out from the sun while the upper region was thought to be caused by ultra-violet light. It was calculated that the path of the particle eclipse should lie to the north and east of the optical path and that the particle eclipse should occur two hours before the other. Since the lower radio frequencies are returned to earth from the lower ionized region at about 100 km. height while the higher frequencies are returned from the upper region at a height of about 220 km. or

more, it was thought that if solar corpuscles were responsible for the lower region ionization, then changes would be noted in the radio signals being returned from that region two hours before the optical eclipse occurred. At Sydney, Nova Scotia, which was within the predicted path of the particle eclipse, a record was made of the virtual height from which reflections occurred for a frequency of 2400 kc. This frequency was ordinarily just low enough to be returned from the lower region during the early afternoon. If particles were largely responsible for the lower region ionization, it was expected that reflections would begin to occur from the upper region by 1:30 P.M. However, no changes were noted until the optical eclipse began to take effect at which time reflections began to come from the upper region.

Besides the observations on 2400 kc. readings were made of critical frequency, which is, roughly speaking, the frequency above which strong reflections do not come from the lower region. This was found to drop with the occurrence of the optical eclipse. Similar observations made in Washington were also described.

It was concluded that ultra-violet light is the principal factor responsible for ionization in both the lower and upper regions. If the effect of solar corpuscles is present, it is small compared to that of ultra-violet light. (*Author's abstract.*)

The above papers were discussed by Messrs. MEGGERS, DAVIS, and TUCKERMAN.

An informal communication was presented by G. H. DRAPER, who discussed Fermat's theorem and concluded with details of his solution of the problem. The communication was discussed by Mr. HEYL.

A second informal communication was presented by W. J. HUMPHREYS, which consisted of a description of a tree that had been struck in a peculiar manner by lightning. The lightning in this case traversed lengthwise through the center of the tree instead of along the Cambium layer, that is just under the bark. The communication was discussed by Messrs. CRITTENDEN and TUCKERMAN.

G. R. WAIT, *Recording Secretary*

1042ND MEETING

The 1042nd meeting was held in the Cosmos Club Auditorium, Saturday evening, October 22, 1932, President TUCKERMAN presiding.

Program: H. L. CURTIS: *The attitude of European laboratories towards absolute electrical units* (illustrated.)—During the summer it was my privilege to visit the Bureau International des Poids et Mesures, the Laboratoire Central d'Electricite, the Physikalisch-Technische Reichsanstalt, and the National Physical Laboratory. At all of these laboratories there is an agreement that units more closely approaching the absolute units should be adopted as early as practicable. Researches are under way to fix units in all the laboratories except the Bureau International des Poids et Mesures. The question naturally arises as to whether the fixing of the units should await completion of all of these researches as well as the researches at the Bureau of Standards and the Japanese national laboratory. The National Physical Laboratory is farthest along with its researches and members of its staff would like to see the absolute units adopted at the earliest possible date. At the Physikalisch-Technische Reichsanstalt, researches on absolute units are just getting well started so that it will be several years before results are obtained. However, many members of the staff feel that the urgency for

changing units is so great that international action should not await completion of these researches. At the Laboratoire Central d'Electricite the staff is agreeable to an early change in the units. I believe that the opinion of the majority of the members of the staffs of these laboratories is that efforts should be made to have the new units adopted January 1, 1935. (*Author's abstract.*)

Discussed by Mr. BRICKWEDDE.

C. MOON: *Some problems encountered in the absolute determination of the ohm* (illustrated).—This paper gives a brief description of the numerous problems encountered in the absolute determination of the ohm from mechanical and electrical measurements on standards of self inductance.

Single layer solenoids can now be constructed so accurately that the uncertainty in their computed inductance due to variations in the diameter and pitch of the winding are negligible. The necessary mechanical measurements of diameter and pitch of the winding can be made with a probable error of only a few parts in a million. In the electrical measurements the maximum variation of a single value from the mean is only one part in one hundred thousand. However, the possibility of an unknown systematic error is somewhat greater than in the mechanical measurements.

Results obtained from measurements on two standard inductors indicate that at the present time resistance can be determined in terms of the fundamental units of length and time with a probable error of less than one part in one hundred thousand. (*Author's abstract*).

Discussed by Mr. MACKAVANAGH.

R. W. CURTIS: *A redetermination of the international ampere in absolute measure* (illustrated).—From the definition of the unit of current it is possible to measure currents by means of the standards of length, mass, and time. The old tangent galvanometer was one method of doing this, but the difficulties are very great when accurate measurements are required.

In this work the force between one coil hung on a balance beam and two other coils is measured. The force depends only upon the current in the coils and the relative positions of the coils. The relative radii of the coils is measured electrically in a separate experiment. By means of this experimentally measured ratio of radii and the experimentally determined force, and the known value of the acceleration of gravity, the current flowing through the coils can be computed. The result is the value of the current in absolute measure. At the same time the current is measured in the usual way with a standard resistance and standard cell, and this result is called the value of the current in international measure. The ratio of the international ampere to the absolute ampere does not depend on the current, and should be constant. The results of this experiment are expressed as this ratio.

Eight experimental determinations of the ratio of radii of four sets of coils gave results which were self-checking and showed errors no larger than ± 6 parts in a million.

Three series of determinations of the force with three sets of coils give results in which the maximum deviation from the mean is about 24 parts in a million. The final result can be expressed as

1 B.S. International Ampere $= 0.99991_9$ Absolute Ampere.

This is in substantial agreement with the result of a similar determination made by Rosa, Dorsey and Miller in 1911, which was

1 B.S. International Ampere $= 0.99992_6$ Absolute Ampere.

(*Author's abstract.*)

An informal communication was presented by F. E. JOHNSON on *Fermat's Theorem.* He analyzed the solution presented informally by G. H. Draper in a previous meeting of the Society and showed that this solution is not valid.

FRANK WENNER, *Acting Recording Secretary*

1043RD MEETING

The 1043rd meeting was held in the Cosmos Club Auditorium, Saturday evening, November 5, 1932. President TUCKERMAN presiding.

Program: W. R. GREGG: *Winds: Some of their characteristics* (illustrated).—Wind is the result of variations in pressure, which in turn are caused by differences in temperature. Because of the earth's rotation the wind does not blow directly from high to low pressure, but is deflected to the right in the northern hemisphere, to the left in the southern. On a level surface, with no friction present, the motion would be at right angles to the pressure gradient, or parallel to the isobars, and the speed would be in accordance with the well-known gradient equations, which involve the pressure gradient, angular velocity of the earth, air density, and latitude. Because of friction and turbulence, however, the theoretical values are never realized at or close to the Earth's surface. The direction is always across the isobars at an angle ranging from 10° to 40°, depending on the amount of friction, and the velocity falls short of the theoretical value by 50 to 200 per cent.

Winds near the earth's surface are, moreover, characterized by an almost endless series of abrupt changes, generally known as gustiness. Sudden departures of the order of 30° to 45° from the mean direction and increases or decreases of 30 to 50 per cent in the velocity are not uncommon. Departures of 90° to 135° in the direction and 60 to 75 per cent in the velocity occasionally occur. Their effect on structures and on the operation of aircraft depends on their abruptness and on the period during which they are maintained. Accelerations of 30 to 50 miles per hour per second have been observed but they continued for only a fraction of a second. Accelerations of 5 to 10 miles per hour per second, lasting for 2 or 3 seconds are, however, quite common. Gustiness is most pronounced during the daytime when thermal turbulence is active. The gusts produced thereby are of much longer periods, often 2 or 3 minutes or more, than are the purely frictional gusts, the latter being superposed on the former.

The effects of gustiness rapidly diminish with height and practically cease at 400 to 500 meters above the surface. At these and greater heights the winds are generally in accord with the gradient equation and, though differing widely in individual cases, on the whole increase with height to the top of the troposphere, about 11 kilometers in middle latitudes, and are prevailingly from a westerly direction. In the stratosphere, where an entirely different type of pressure and temperature distribution prevails, the winds are variable in direction and decrease markedly in velocity. (*Author's abstract.*)

Discussed by Mr. HUMPHREYS.

F. NEUMANN: *Vibration observations in the Washington Monument* (illustrated).—A small portable experimental seismograph developed by the Coast and Geodetic Survey, in connection with the study of destructive movements in the central region of an earthquake, was set up several times in the Washington Monument to test its performance. The data thus obtained are of special interest to engineers and physicists desiring to study the

physical characteristics of tall structures. It was pointed out that the recorded movements are so small that for all practical purposes they can be considered negligible, certainly so when compared with the vibrations of tall office buildings. As the maximum displacements in a strong wind are only a few thousandths of an inch they can be observed only with a very sensitive type of seismograph, an instrument of the same order of magnification as found in modern seismographic equipment for recording the unfelt vibrations emanating from distant earthquakes.

The instrument used is a pendulum of 1 oz. mass suspended at the free end of a flat spring free to vibrate horizontally. Damping is obtained through the frictional characteristics of a thin film of castor oil inserted between the bottom of the disk-shaped mass and the smooth surface of a glass or metal platform built beneath the mass. A mirror axle of 1 mm. diameter, suspended vertically, furnishes one of the elements of the magnifying system, which is optical. In practice this axle is suspended from a fine silk thread as a safety measure, but the thread plays a negligible part in the instrument performance. Two very fine phosphor-bronze ribbons which are strung horizontally close to the axle, are cemented to the frame at their four terminals and each is wound one time around the mirror axle in the same direction. A similar ribbon, strung parallel to the other two, is cemented to the ends of an adjustable fork or prong fixed to the steady mass and projecting a short distance beyond it. This ribbon is wound around the mirror axle in a direction opposite to that of the other two. The effect of the combination is such that when the pendulum is displaced a slight amount of the ribbon strung across the end of it causes the mirror axle to rotate on the other two ribbons which may be considered as taking the place of a jewel and pivot bearing. The advantages of this scheme are the practical elimination of lost motion, a minimum of friction and high magnification. The ribbons are 0.01 mm. thick and 0.1 mm. wide; magnification can be varied from 1000 to several thousand, and periods from 1/15 second or less to 1 second. A suitable recording apparatus for photographic registration is part of the assembly.

The fundamental vibration period of the monument was found to be 1.81 seconds. An overtone of 0.6 second period was observed visually and is vaguely evident in some of the photographic records. On another occasion a period of 0.2 second appeared as the outstanding characteristic of the record, and again, during a gusty type of rain-storm the dominant vibrations were close to 0.06 second or a frequency of 17 per second. These few observations are insufficient to explain the various modes of vibration, especially in view of the fact that only one component of a 3-dimensional type of vibration was recorded. The value of the fundamental period and overtones are of the order to be expected, but the observed frequency of 17 oscillations per second appears to the physicist as a rather curious phenomenon. (*Author's abstract.*)

Discussed by Messrs. HUMPHREYS, STIMSON, HAWKESWORTH, BLAKE, HECK and DRYDEN.

H. L. DRYDEN: *Wind pressure on a model of the Empire State Building* (illustrated).—When the Empire State Building was constructed in New York City, provision was made through the cooperation of architects, engineers, and owners to have the building serve as a laboratory for obtaining more accurate knowledge of wind pressure. Under the direction of the committee on research of the American Institute of Steel Construction, thirty pipes were placed at the 36th, 55th, and 75th floors, transmitting the pressure from small openings in the exterior faces of the building to accessible places

on each floor. In addition, some of the steel columns under the tower portion of the building on the 23rd floor were provided with strain gauges for determining strains in the columns due to wind. Instruments for measuring the direction and velocity of the wind were mounted on the top of the building.

The forecasting of the wind pressure to be expected on a building has many of the aspects of a game of chance. It is practically certain that the speed of the wind will exceed 5 miles per hour at some time during nearly every day of the year. In Washington, D.C., the speed will exceed 40 miles per hour about four times a year. It has not blown at a speed of 100 miles per hour at the Weather Bureau station in Washington, D.C., in the sixty years or so that records are available. It is a practical impossibility to design all buildings to withstand the maximum speeds which have ever been experienced anywhere. The engineer must draw the line at some speed which is not likely to be exceeded in the life of the building. To obtain information of this kind from direct observations on a building would require years of measurements, and a statistical study of the results. Moreover, the results would not necessarily be applicable to some other building of a different shape.

The only long-continued observations on the wind are those made by the Weather Bureau. These observations give the wind speeds, and to determine the pressure on the building, the relation between the pressure and the speed must be known. The method of obtaining this relation, which is now coming into use, is that of making measurements on models in a wind tunnel, a device in which artificial winds may be produced. Although the method of model-testing is well known in hydraulics and aeronautics and has been found invaluable, it is new to structural engineers. Full confidence has not been placed in the results, because of some feeling of uncertainty as to the application to buildings in the natural wind. When the program of the American Institute of Steel Construction to be carried out on the Empire State Building was announced, the Bureau of Standards saw an opportunity to demonstrate the utility and validity of model measurements. Experiments have been completed on a model of the building at the Bureau of Standards. When the results on the actual building are finally available, comparisons can be made.

The Empire State Building is 1250 feet high; the model is 5 feet high. On this scale the height of a man would be a little more than one-quarter inch. The model is built of aluminum plates to the exterior shape of the building omitting minor irregularities of the surface. It does not represent the actual building in material, method of construction, or strength. It is not tested to failure but is used only for measurements of wind pressure. Small holes in the outer walls are connected by rubber tubing to a pressure gauge. The air near the surface of the model pushes on the air in the rubber tubing with the same pressure as on the neighboring solid wall of the model. The pressure is transmitted to a gauge where it is balanced by the weight of a column of liquid. In some tests the model was mounted in bearings and the overturning moment measured.

The artificial wind was produced in the 10-foot wind tunnel of the Bureau of Standards, in which speeds up to 70 miles per hour may be obtained.

Under normal conditions, with no wind blowing, the surfaces, both interior and exterior, of all buildings, are subjected to the normal atmospheric pressure of 14.7 pounds per square inch. When the wind blows, this pressure is modified. In some places the pressure increases, in others it decreases by amounts which usually do not exceed a few tenths of a pound per square

inch. When the pressure is reduced below the normal atmospheric pressure, the effect is often called a suction. The results on the model of the Empire State Building, show as for other models tested that the pressure varies greatly from point to point and that suction effects predominate. The greatest loads on the building occur when the wind blows directly against one face. The average pressure is of the order of 35 to 40 pounds per square foot at a wind speed of 100 miles per hour. At other wind speeds, the pressure varies as the square of the speed, i.e., at 50 miles per hour, it is only 9 or 10 pounds per square foot.

It was found that the speed of the air rushing by close to the building is greater than that of the approaching wind. Thus the instrument on the building gives a speed about 20 per cent greater than the speed of the wind approaching the building.

The detailed results giving charts of the distribution of pressure with the wind striking the model from different directions will be published in a few months as a Research Paper of the Bureau of Standards. (*Author's abstract.*)

Discussed by Messrs. HECK, BITTINGER, and HAWKESWORTH.

1044TH MEETING

The 1044th meeting was held in the Cosmos Club Auditorium, Saturday evening, November 19, 1932, President TUCKERMAN presiding.

Program: D. H. ANDREWS, Professor of Chemistry in The Johns Hopkins University: *Models of vibrating molecules* (illustrated).—Before the advent of the new quantum mechanics we thought and talked of atoms and molecules in terms of definite models which were useful in the formulation of mathematical equations and in the physical interpretation of the results of theoretical and experimental investigations. In the new mechanics, models are so difficult to construct that they are little used, and with the annunciation of Heisenberg's Uncertainty Principle, their overthrow as a useful aid seemed complete. Models were replaced by mathematical abstract quantities, like ψ, and by symbolisms. It is interesting that Professor Andrews is using models to obtain *quantitative* results that are useful, not only in correlating the results of numerous investigations of Raman spectra of complex molecules, but also in discovering facts previously unknown.

Professor Andrews demonstrated models which he had used in the study of the modes and frequencies of the vibratory motions of atoms in molecules. The atoms were replaced by steel balls connected by springs to represent the chemical bonds holding them together. The ratios of the masses of the steel balls are as the ratios of the atomic weights of the atoms and the springs were so selected that their stiffnesses correspond with the relative strengths of the bonds. The models are suspended freely and are made to vibrate by a variable-speed motor to which they are loosely coupled. In order to make it possible to see and count the vibrations, the illumination of the model was periodically varied so that the observed frequency of vibration of the atoms was only 1/20th the actual frequency. When the frequency of the motor corresponds with a natural frequency of the model it vibrates in resonance with the motor, but when the speed of the motor is increased or decreased a little the model ceases to vibrate. Starting with the motor turning slowly, one observes, if its speed is increased continuously, one after another of the different modes of vibration of the molecule. The corresponding frequencies of vibration are the frequencies of rotation of the motor.

Although the agreement of the model frequencies with the known molecular frequencies determined spectroscopically is not exact, the correspondence

is close. This makes it possible to determine the modes of vibration corresponding with the numerous frequencies obtained from Raman spectra investigations. There are cases where frequencies were first observed with the model and later found in the Raman spectra. By combined model and Raman spectra investigations of homologous series, one is enabled to follow the changes in molecules as new groups are added one after the other. With the models information can be obtained as to the structures of molecules as was obtained for example with regard to the position of the double-bond in benzene, and the angle between the C-Cl bonds in $C\ Cl_4$. (*Abstract prepared by* F. G. BRICKWEDDE.)

Discussed by Messrs. RAMBERG, HERSEY, WHITE, TUCKERMAN, CURTIS, GIBSON, HUMPHREYS, and BRICKWEDDE.

An informal communication was presented by W. P. WHITE, in which he described a method of preparing an ice-bath of very constant temperature.

1045TH MEETING

The 1045th meeting, constituting the 62nd annual meeting, was held in the Cosmos Club Auditorium, Saturday evening, December 3, 1932, President TUCKERMAN presiding.

The treasurer reported expenditures of $1500.19 and stated that the number of active members is 275.

The Secretaries reported that the following new members were elected during the year: CLYDE S. AITCHISON, MISS ELIZABETH W. ALDRICH, L. B. ALDRICH, REBECCA E. ANDREWS, DAVID W. ARMSTRONG, EMMETT CHESTER BAILEY, P. S. BALLIF, HERBERT GEORGE BAROTT, HOWARD S. BEAN, FORREST GARY BITNER, RAYMOND B. BLOCK, ROY C. BOWKER, F. S. BRACKETT, DONALD B. BROOKS, DONALD M. BROWN, SIDNEY H. BROWN, HOWARD A. BUCHHEIT, FRANK R. CALDWELL, JAMES ROBERT COE, JR., RAYMOND DAVIS, ORRIN M. ELLIOTT, MELVIN F. FISCHER, CYRUS C. FISHBURN, JAMES FULTON FOX, RALPH W. FRENCH, FREDERICK H. GOLDMAN, CARLETON B. GREEN, HOMER A. HAMM, ROBERT C. HARDY, ORLANDO J. HODGE, W. H. HOOVER, MISS M. LANGHORNE HOWARD, CURTIS J. HUMPHREYS, S. H. INGBERG, DEANE B. JUDD, H. K. KING, FREDERICK L. KNOWLES, FRANK C. KRACEK, MISS CHARLOTTE M. KRAMPE, W. LERCH, MRS. ISABEL MARTIN LEWIS, HENRY MATHESON, E. D. MCALLISTER, PAUL A. MCNALLY, ARCHIBALD T. MCPHERSON, PAUL S. MURPHY, REV. JOHN S. O'CONOR, S.J., GEO. C. PAFFENBARGER, OLIVER SCOTT READING, W. A. ROCHE, WILLIAM FREDERICK ROESER, CARL RUSSO, PRENTIS D. SALE, JR., MRS. ELSIE W. SHAW, E. R. SHEPHARD, JOHN C. SOUTHARD, SYDNEY STEELE, LOYD A. STEVENS, ALLEN RAYMOND STICKLEY, WM. H. SWANGER, HERBERT C. S. THOM, JOHN TUCKER, JR., DAVID LINDSAY WATSON, CLARENCE C. WEIDEMANN, EDWARD WICHERS, and J. U. YOUNG.

The following deaths were reported: LOUIS WINSLOW AUSTIN, LOUIS A. BAUER, GEORGE K. BURGESS, ROBERT L. FARIS, HENRY MARTIN PAUL, IRWIN G. PRIEST, and FREDERICK W. STEVENS.

The following officers were declared elected for the year 1933: *President,* O. S. ADAMS; *Vice Presidents,* H. L. DRYDEN and O. H. GISH; *Recording Secretary,* F. G. BRICKWEDDE; *Treasurer,* E. W. WOOLARD; *Members-at-large of the General Committee,* L. B. ALDRICH and H. T. WENSEL.

During the year the second Joseph Henry lecture in memory of the first President of the Philosophical Society was given by A. E. KENNELLY, Professor Emeritus of Electrical Engineering at Harvard University.

At the conclusion of the business meeting, F. B. SILSBEE read a paper on *Superconductivity.*—This paper summarizes the more outstanding facts which have been found during the 21 years since the property of superconductivity was discovered by Professor Kamerlingh Onnes at Leiden. Most of these facts are the result of work at Leiden, but during the last few years many valuable contributions have come from the German Reichsanstalt and from the University of Toronto.

Superconductivity, like cosmic radiation and radioactivity, is one of the relatively few phenomena of physics which has been discovered unexpectedly, rather than as the result of a deliberate search. The electrical resistances of certain substances such as mercury, lead, and tin at the very low temperature made available by the use of liquid helium, drop abruptly at their respective critical temperatures, 4.2°K, 7.2°K, and 3.7°K, to values too small to measure. In the case of lead the resistance has been found to be certainly less than 10^{-12} times the resistance of the same specimen at room-temperature. This superconducting state is destroyed and normal resistance abruptly restored if the substance is placed in a sufficiently strong magnetic field, or if the electric current used in measuring the resistance is so great as to produce a magnetic field of the critical value.

Changing the crystal state of the metal as in the change from the ordinary "white" tin to "gray" tin also destroys the superconductivity.

Other materials which have been found to show this property are the elements, gallium, indium, thallium, titanium, thorium, columbium, tantalum, and such compounds as the nitrides of titanium, vanadium, circonium; the carbides of titanium, tungsten, molybdenum, tantalum, columbium, and zirconium; and the sulphides of copper and of lead. An alloy of gold and bismuth is also superconducting at 1.8°K, although neither of the separate constituents shows this property when tested down to 1.5°K.

This astonishing change by a factor of a million million is one property which does not seem to be accompanied by any abrupt change in any other properties. The crystal structure as revealed by X-rays, the thermal expansion, coefficient of torsional rigidity, and thermal conductivity all change but little and in a perfectly continuous fashion as the material is cooled down through its critical temperature.

The experiments so far performed have raised more questions than they have answered. Is the increased conductivity the result of an increased number of carriers of electricity, or of an increased freedom of those already present? Is the resistance below the critical temperature truly zero, or does it have a finite value beyond the limit of the methods of measurement thus far tried? Will all metals, and perhaps all substances, be found to be superconducting if cooled to a sufficiently low temperature? And, most tantalizing of all, will any substance be found which under certain conditions will be superconducting at ordinary temperatures and thus revolutionize the art of electrical engineering? (*Author's abstract.*)

Discussed by Messrs. CURTIS, WHITE, BARROWS, BRICKWEDDE, GOLDMAN, HAWKESWORTH, HUMPHREYS, BUCKINGHAM, and TUCKERMAN.

G. R. WAIT, *Recording Secretary*

BOTANICAL SOCIETY

240TH MEETING

The 240th regular meeting was held in the Assembly Hall of the Cosmos Club on March 1, 1932. President J. B. S. NORTON presided; about 145 were present.

L. E. YOCUM was elected to membership.

Brief notes and reviews: M. B. WAITE exhibited daffodils from his yard. He recalled that in 1890 there was a similar mild winter. F. V. COVILLE and A. S. HITCHCOCK reported further upon seeds caught from airplanes. J. S. COOLEY exhibited a culture of *Xylaria malli* showing zonation. J. B. S. NORTON reported finding sclerotia of brown rot of peaches one half to three fourths of an inch long. M. B. WAITE reported peaches in bloom in Arkansas, whereas here and in Georgia the buds have not swollen, being still dormant due to lack of chilling. R. F. GRIGGS exhibited a culture of liverwort growing on nitrogen-free agar which was strongly phototropic.

Program: W. J. MORSE: *Agricultural explorations in Japan, Korea and Manchuria.*—Illustrated by four reels of motion pictures taken by the speaker during his two year stay in the Orient. Culture of soybeans and utilization of the crop was shown in detail. Other scenes illustrated the growing of rice, small fruits and other crops, as well as the Japanese cherry tree and other ornamentals in bloom, and the collecting, packing and shipping of the material collected.

After adjournment, soybean cheese sandwiches and soybean chocolate milk were served. Other soybean food products were exhibited.

SPECIAL MEETING

A special meeting was held in the Conference Room of the Administration Building, U. S. Department of Agriculture, March 22, 1932. President J. B. S. NORTON presided; 47 members and guests were present.

Program: T. H. HARRISON, plant pathologist of New South Wales: *Plant Pathology in Australia.*—The speaker outlined the principal physical and climatic characteristics of the states of Australia together with a brief statement of the organizations which are responsible for scientific work. From the investigator's viewpoint, Australia is a very young country. Although the size of the United States of America, it has only about seven million inhabitants. Only the easily accessible and fertile land has been developed. Crops grown and the diseases which attack them were discussed in detail, many being illustrated by lantern slides.

241ST MEETING

The 241st regular meeting was held at the University of Maryland, April 5, 1932. President NORTON presided; 179 members and guests were present.

Dinner was served in the College dining hall at 7:30. This was followed by a dramatic sketch put on by a small group of University of Maryland students, entitled, "Suppressed Desires."

Program: B. Y. MORRISON: *English Gardens.*—The speaker visited several of the famous gardens in England and had an opportunity to observe the personal interest which the Englishman takes in his garden. Exhibits of Narcissi illustrated the results of crossing certain strains.

242ND MEETING

The 242nd regular meeting was held in the Assembly Hall of the Cosmos Club on May 3, 1932. President J. B. S. NORTON, presided; attendance 66.

MISS VIVIAN KEARNS was elected to membership.

Brief notes and reviews: FRANK THONE exhibited four new volumes, Baillieres Encyclopedia of Scientific Agriculture; Proceedings of the 5th International Botanical Congress at Cambridge; Murray's Planning and Planting the Home Garden; and Life of Mendel. C. A. LUDWIG exhibited

cowpea, alsike clover and Lespedeza plants grown without sunlight. J. B. S. NORTON showed an unusual violet.

Program: K. D. DOAK: *Mycotrophic habit in Allegheny forest trees.* (Illustrated by lantern slides).—Discussed by C. A. LUDWIG, J. B. S. NORTON, F. THONE, C. HARTLEY, R. D. RANDS and others.

J. S. COOLEY: *Some wild flowers of Oregon.* (Illustrated by lantern slides.) —Discussed by D. GRIFFITHS, R. K. BEATTIE and M. C. MERRILL.

ANNUAL OUTING

The annual outing was held at the Montgomery Sycamore Island Club on June 4, 1932, attendance, 115. Games and swimming were enjoyed. About 5 o'clock coffee and ice cream were served by the Society to members and guests who provided their own lunches.

NATHAN R. SMITH, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

Death Valley now a National Monument.—An important step in the development of the U. S. National Park system was taken on February 11, when by presidential proclamation the greater part of Death Valley was withdrawn from the open public domain and given the status of a national monument. The area set aside is 1,601,800 acres in extent, and takes in about two-thirds of the total land in the valley. It includes particularly the land below sea level, which is the lowest point in the Western Hemisphere. Within the area are such notable natural features as Telescope Peak, Furnace Creek, and the Ubehebe Crater. Within it also is the famous Death Valley Scotty's Place, a fantastic rococo palace built by a "character" who seems to have money to burn and chose to spend it on building.

Abbé Lemaitre lectures in Washington.—The abbé GEORGES LEMAITRE, noted physicist of the University of Louvain, lectured at the Catholic University of America on January, presenting some of his views on the "expanding universe" postulated by Einstein and De Sitter, for whose divergent theories he has found mathematical reconciliation. Extrapolating the cosmic expansion backwards in time, Abbé LEMAITRE comes to a beginning as a single atom of sufficient mass (or its energy equivalent) to have since formed all the matter in the universe. The initial explosion of this cosmic atom the Abbé sees as the origin of the cosmic rays, which are thus as old as the universe itself.

Mechanical tabulation of oceanographic data.—The problem of utilizing the information relating to ocean currents, sea temperatures, and concomitant phenomena contained in the thousands of reports received monthly by the Hydrographic Office of the U. S. Navy has been greatly simplified by the use of electrical punching, sorting and tabulating equipment, recently installed.

This system is one in which data are represented by holes punched in certain positions on a card. The punched cards can then be sorted into desired groups, by an electrical sorting machine, and finally tabulated and analyzed by an electrical tabulator which prints a record of the operation.

Static bearing indicators.—The Navy has been interested for many years in the correlation of static with violent weather disturbances. Experiments have been conducted with various types of instruments and it has been found that the use of a cathode ray tube to show the direction of incoming atmospherics is the most promising.

Two such instruments have been designed and manufactured at the Naval Research Laboratory and are now ready for installation. It is planned to locate them at Naval direction finder stations in Florida and Texas, so that by plotting instantaneous cross bearings of incoming atmospherics, weather disturbances can be located even in the absence of ship reports.

Public health work in Costa Rica and Cuba.—In the February issue of the *Bolétin de la Oficina Sanitaria Panamericana*, Drs. A. Pena Chavarria and Mario Lujan report the results of the Dick test in Costa Rica. Among 852 persons, 21.4 per cent proved positive, as compared with 34.4 per cent (Zingher) in New York City and 13.1 per cent (Doull, et al.) in Rio. The percentage of positivity decreased in San Jose from 55 per cent in infants under 1 year to 38 per cent, in children 1 to 4 years; 24.4 per cent, 5 to 9 years; 22.2 per cent, 10 to 14 years; 18.2, 15 to 19 years; and 13.2 per cent in persons over 20.

Among persons of the white race, the percentage was 20.9 in the urban districts and 20 in the country sections, compared to 26.1 and 17.3, respectively, among persons of mixed races. These tests were made during a recent epidemic of scarlet fever in Costa Rica. This epidemic proved one of the most extensive ever observed in the country, and judging from its renal complications, the most serious so far during the present century. The disease is very rare in Costa Rica, and the records only show an epidemic in 1901 and another in 1865.

Dr. Pena Chavarria had previously made similar studies with the Schick test in Costa Rica and Colombia.

Vernon Bailey returns.—After conducting a three-months biological expedition in northern Mexico, Vernon Bailey returned on January 25 to his Washington headquarters in the Bureau of Biological Survey, United States Department of Agriculture. With Frederic Winthrop, Jr., of the Museum of Comparative Zoology, at Cambridge, Mass., and Bernard Bailey, a collector from Escondido,Calif., he covered a section of country extending from the backbone of the Sierra Madras at 8,500 feet down to sea level on the Gulf of California, near Tiburon Island. This section included parts of all the life zones between the Canadian and Tropical, with the accompanying wide variation and complexity of plant and animal life. Besides making an excellent mammal and bird collection, which is to be divided between the Biological Survey and the Museum of Comparative Zoology, the expedition gathered a wealth of valuable information on habits and distribution of species and on the limits of the life-zone areas of the region and their relation to those of the United States.

Examine more than 2,000 mammal stomachs.—The Biological Survey's food-habits research laboratory, in Denver, Colo., during 1932 received 4,260 mammal stomachs, including more than 3,600 of coyotes and 370 of wild cats. The laboratory reports that 636 of the 2,663 stomachs studied were empty and 535 contained only debris picked up by the animals while in traps. Valid data were thus collected of the contents of 1,492 stomachs, 1,379 of which were of coyotes.

News Briefs

Chinese civilization dates back only to about 2000 B.C., and is thus much more recent than that of the Nile-Mesopotamia-Indus area, an investigation by C. W. Bishop, curator of the Freer Gallery, indicates. Mr. Bishop obtained his data by adding up the probable durations of the reigns of monarchs in the Chinese dynasties. According to his chronology, the Hsia dynasty, the first of "civilized China" began about 1800 B.C.

On December 30 the United States Department of Agriculture issued Importation Permit No. 20,000. Dr. T. S. Palmer, of the Bureau of Biological Survey, who is in charge of the work, says this means that since the passage of the Lacey Act on May 25, 1900, permits have been issued for the entry of 20,000 separate shipments of birds and mammals.

Personal Items

Dr. Theobald Smith, who was the first chief of the pathological division of the Bureau of Animal Industry, recently retired as director of the Rockefeller Institute at Princeton University. It was Dr. Smith who discovered, while he was a member of the department that the cattle tick carries tick fever from one animal to another, a discovery which paved the way for the later discovery that the mosquito transmits malaria and yellow fever.

Walter G. Campbell, Director of Regulatory Work in the U. S. Department of Agriculture, resigned to become Chief of the Food and Drug Administration in the department, effective February 1. The position of Director of Regulatory Work has been abolished.

Dr. Walter Hough, Head Curator of Anthropology, has gone to Arizona, for a two-month sojourn among the Pima Indians of the Mexican border. Dr. Hough expects to obtain photographs of fast-vanishing types, and also to inspect archaeological undertakings now under way in that area.

Dr. W. D. Strong, of the Bureau of American Ethnology, sailed January 28 for Hondruras, where, in company with Alan Payne and Norman Haskell, he will conduct archaeological researches in the Chorotegan area. One of the principal objects of the expedition is the search for a reported "stone city" in the region of the Patuca River.

Miss Emma Reh, formerly of Washington, now Science Service correspondent in Mexico City, is at present in the field in the State of Oaxaca with a party of Mexican archaeologists, exploring the famous tomb group at Monte Alban and investigating other sites.

Dr. Emmet W. Price, parasitologist, Zoological Division, United States Bureau of Animal Industry, left Washington January 19 for Puerto Rico, as one of a group of scientists, headed by Dr. Paul Bartsch of the Smithsonian Institution, who will spend two months in the Caribbean.

Ernest J. Greenwalt has been appointed agent and United States deputy game warden to supervise the Charles Sheldon Wild Life Refuge, Nevada, which is administered by the Bureau of Biological Survey, in cooperation with the National Association of Audubon Societies, chiefly for the protection of antelope.

E. N. Munns, in charge of the Division of Silvics, U. S. Forest Service,

has been elected vice president of the Permanent Committee, governing body of the International Union of Forest Research Organizations.

Dr. WILLIAM BOWIE, Chief of the Division of Geodesy, U. S. Coast and Geodetic Survey, has been awarded the Charles Lagrange prize by the Royal Academy of Belgium in recognition of his having effected the unification of the triangulation systems of Canada, the United States, and Mexico. This prize is awarded once in four years for work done which adds to the mathematical knowledge of the earth.

Obituary

Dr. FRANCIS LA FLESCHE, of the Bureau of American Ethnology, died September 5, 1932. Dr. La Flesche was born in Thurston County, Neb., Dec. 25, 1857. He was three-quarters Indian, his father being Estamaza, a half-blood who was the former head chief of the Omaha tribe, and his mother a full-blood Indian. He became prominent in 1878–1879 when he and his elder sister Susette accompanied the Ponca chief Standing Bear in his journey to the East. Here the wrongs which the Ponca (a tribe whose language is nearly identical with that of the Omaha) had suffered were exposed. This led to his appointment in 1881 in the Office of Indian Affairs where he remained for years. After being loaned to the Bureau of American Ethnology, eventually he was transferred to the latter institution. His most important works are The Omaha Tribe (with Alice C. Fletcher), The Osage Tribe: rite of the chiefs; The Osage Tribe: rite of the Waxo be; The Osage tribe: the rite of vigil; The Osage Tribe: two versions of the child-naming rite; A dictionary of the Osage language. He was president of the Anthropological Society of Washington in 1922–23. In 1926 the degree of Doctor of Letters was conferred upon him by the University of Nebraska.

Miss HELEN E. STOCKBRIDGE, librarian of the U. S. Forest Service, died December 20, 1932.

Mr. ERNEST DANGLADE, formerly of the U. S. Bureau of Fisheries, died December 18, 1932, at Vevay, Indiana.

ANNOUNCEMENTS OF MEETINGS

The ACADEMY announces a meeting on March 23, 1933. Members of the Academy and their wives will gather at the East Building of the Bureau of Standards, at 8 P.M., for the purpose of viewing scientific exhibits. The exhibits will cover the different fields in which Academy members are interested, including, among others, biology, chemistry, geology, and physics. An exhibit of special interest to the ladies will be shown.

The Philosophical Society announces the following programs:

March 25. *Studies of atomic nuclei at the Department of Terrestrial Magnetism.*

April 8. R. WIEBE.—*The experimental determination of some properties of gases up to 1000 atmospheres.*

W. E. DEMING.—*Some thermodynamic properties of real gases from compressibility data.*

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GEOPHYSICS.—*The thermal history of the earth.*[1] Arthur Holmes, The University, Durham, England.

Speculation as to the thermal behavior and cooling history of the earth has been vigorously stimulated in recent years by the discovery that the radioactive elements constitute an important source of internal heat. Despite the vast store of data accumulated since Hopkins grappled with the problem nearly a hundred years ago, the constitution of the earth and the physical properties of its materials are still inadequately known, and in consequence every worker in this field finds an uncharted margin in which the undetermined conditions governing the earth's thermal history offer a considerable range of personal choice. It is for this reason that the field is occupied by several types of competing hypotheses.

RIVAL HYPOTHESES

The time-honoured "contraction hypothesis," made familiar by Kelvin, has been ably rejuvenated by Jeffreys (23). Joly, on the other hand, departing widely from traditional lines of treatment, has introduced a "hypothesis of thermal cycles" which has aroused world-wide interest and discussion (26). Convective circulation within the earth was envisaged by Hopkins in 1839 and later by Fisher (10), and a "hypothesis of sub-crustal convection currents" (maintained by the earth's radiothermal energy) is now being actively explored by Bull (6) and myself (16).

To the onlooker this overcrowded field of speculation may seem to be in a distressingly chaotic state. The occasion of this address provides me with a welcome opportunity to attempt to tidy it up. I

[1] Lecture delivered before a joint meeting of the Washington Academy of Sciences with the Geological Society of Washington on April 7th, 1932. Received January 29, 1933.

propose to offer a critical survey of the whole field by systematically reviewing the physical assumptions involved in each type of hypothesis and by confronting the geological consequences of each with what is known of the realities of earth history.

RADIOTHERMAL ENERGY OF THE ROCKS

The downward increase of temperature which is everywhere encountered in the earth's crust indicates beyond doubt that the earth is losing heat. In itself, however, this fact of observation does not necessarily imply that the earth is cooling. If the interior were being heated up, heat would still be lost by conduction through the crust and radiation into space. In the well known treatment of the problem by Kelvin a steadily cooling earth was not unnaturally assumed. Kelvin regarded the earth as a spendthrift living on her inherited capital of cosmic heat. He considered (always provided that no internal supply of heat was available to counterbalance the external loss) that the present rate of cooling was represented by the average downward temperature gradient. The process of solidification from a molten state was interpreted in accordance with the belief that crystallization would begin at the surface, as happens in the lava-filled crater-sink of Halemaumau. By the formation of a succession of thin solid shells, each of which in turn broke up and sank, the earth would become a honeycombed solid enclosing cells of magma which remained available for the vulcanism of future geological ages.

To geologists the chief symptom that suggested a flaw in Kelvin's premises was his calculation that the consolidation of the crust occurred at some time between 20 and 40 million years ago. So short an allowance for geological time was widely regarded as hopelessly inadequate. The radioactive elements and their output of heat were at that time still unrecognized. But with the discovery of radioactivity and Strutt's demonstration (32) that traces of radium could be detected in all rocks, it became certain that the earth could no longer be regarded as simply a cooling body free from internal sources of heat. The long controversy came to an end with the realization that the earth must have cooled down—if at all—much more slowly than Kelvin had thought possible, and that in consequence the earth's age must be immensely greater than 40 million years.

Although the amount of radium (representing the uranium family) in rocks is very minute, the thermal effects are startling in their implications. It can easily be shown that all the internal heat lost from the earth's surface could be supplied by 1 ounce of radium in every

1000 million tons of the material of the earth. Actually the proportion in the rocks of the accessible crust averages about 1 ounce in 20 million tons. That is to say, if radium were distributed throughout the earth in the proportions characteristic of rocks the income of heat would be fifty times as great as the expenditure. Moreover, when the thermal effects of thorium and potassium are taken into account the income is found to be doubled. As we cannot believe that the earth is being heated up at this embarrassing rate, we must conclude with Strutt (Lord Rayleigh) that the radioactive elements are practically confined to a radioactive layer which corresponds with a crust a few tens of kilometers in thickness.

The suggestion that much of the energy liberated by the radioactive elements in rocks might not appear as heat has been shown by Lawson (28) and others to be entirely without foundation. Thus, if the radioactive elements are present in the substratum and core, either they must be excessively rare or their radioactivity must be in some way inhibited. The second of these alternatives is quite untenable in the light of direct experiments and modern atomic theory, but even if it were not, the reality of the radioactive layer would still remain.

Since the pioneer work of Strutt on the distribution of uranium and thorium in rocks, many other determinations have been made, notably by Joly and his co-workers, and in America by Piggot. In Figs.

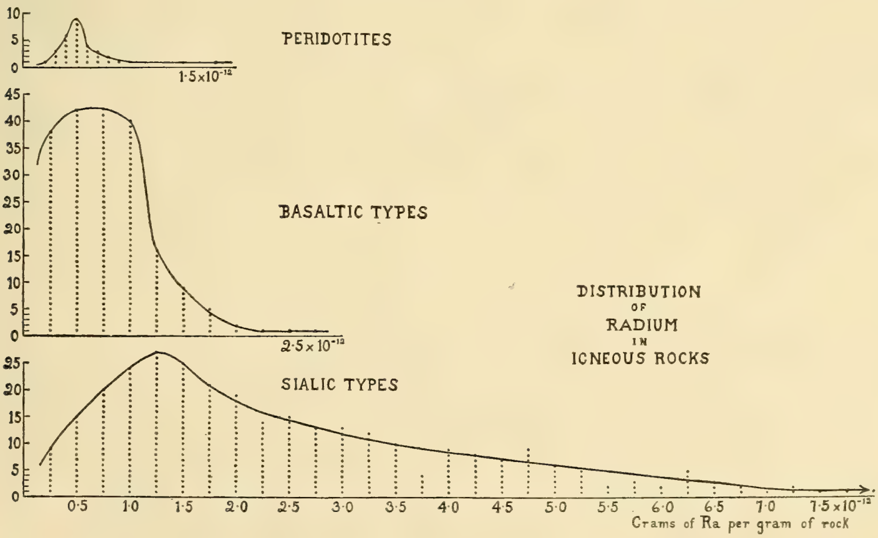


Fig. 1.—Frequency diagrams to illustrate the distribution of radium (representing the uranium family) in the three chief groups of igneous rocks.

1 and 2 I have summarized all the reliable data at present available, in the form of frequency diagrams for each of the chief groups of crustal rocks. It will be seen that, despite a considerable amount of overlapping, the rocks of sialic composition as a whole are richer in uranium[2] and thorium than those of basaltic composition, and that these in turn are richer than the rocks of peridotitic composition. It is well known that the same order is followed by potassium. Although potassium is but feebly radioactive, its aggregate heat output is important in virtue of its relative abundance in rocks.

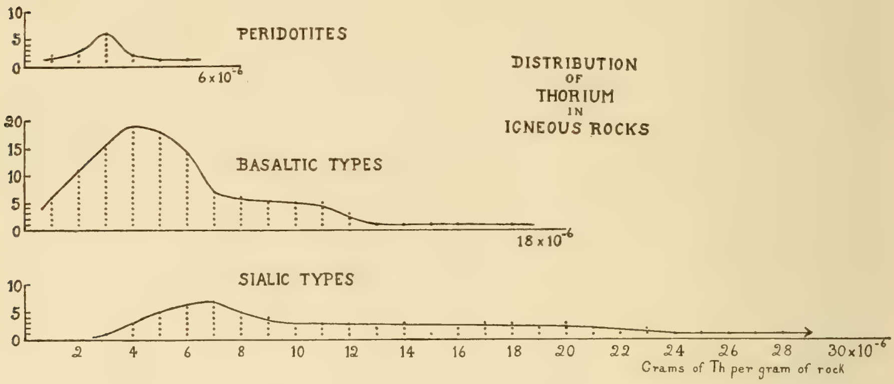


Fig. 2.—Frequency diagrams to illustrate the distribution of thorium in the three chief groups of igneous rocks.

The average contents of uranium and thorium in basaltic and peridotitic rocks correspond closely with the peak-values revealed by the frequency diagrams, but this is far from being true of the sialic rocks. Each of the sialic diagrams could be continued indefinitely to the right in consequence of the fact that the radioactive elements tend to be concentrated in magmatic residual liquids. The averages of all the data plotted for sialic rocks are:

$$\text{Radium} = 2.36 \times 10^{-12} \text{ gm./gm. i.e. Uranium} = 7.08 \times 10^{-6} \text{ gm./gm.}$$
$$\text{Thorium} = 14.8 \times 10^{-6} \text{ gm./gm.}$$

There can, however, be no doubt that these figures are too high to be representative of the Upper or "Granitic" Layer of the crust, since differentiation products in the liquid line of descent are strongly concentrated towards the surface and therefore over-weight the apparent average. I propose, therefore, to take the peak-values of the sialic diagrams as representing the most probable averages that can be derived from present data. For thorium the peak-value is ill-defined

[2] The radium contents are plotted in Fig. 1. Uranium $=3\times10^6$ Radium.

owing to the paucity of determinations. Nevertheless, it is thought advisable to adopt the figures given below—tentative though they be—in preference to the much higher averages that have hitherto been used for the sialic rocks of the upper layer. The averages selected are as follows:

Groups of Rocks	Uranium per 10^6 gm.	Thorium per 10^6 gm.	Potassium per 10^2 gm.
Sialic	3.75	7.0	2.7
Basaltic	2.1	5.0	0.8
Peridotitic	1.5	3.1	0.3

The order corresponds with the general downward distribution of rock-groups in the continental crust and itself constitutes evidence of a marked upward concentration of the radioactive elements. The averages for sedimentary rocks are near those here given for sialic crystalline rocks and no serious error will be involved by grouping the sediments with the latter.

It should be noticed that, however the data are treated, the inference is confirmed that acid rocks are, on an average, richer in the radioactive elements than basic rocks. The doubt as to this, recently expressed by Bailey Willis (36), is raised only by a comparison of overlapping results and is found to be baseless when the whole of the data is examined.

The rates of liberation of energy from the radioactive elements expressed as annual outputs of heat are:

Uranium family	$7{,}900 \times 10^{-4}$ cals./gm. U.
Thorium family	$2{,}300 \times 10^{-4}$ cals./gm. Th.
Potassium	*ca.* 0.2×10^{-4} cals./gm. K.

Combining the data of the above tables we arrive at the following annual outputs of heat in average rocks:

Groups of Rocks	Total Annual Output in Calories per 10^6 gm.	per 10^6 cc.
Sialic	5.0	13.7
Basaltic	3.0	9.0
Peridotitic	2.0	6.8

DISTRIBUTION OF RADIOACTIVITY IN THE EARTH

Seismic evidence suggests the following downward succession for certain continental regions:

Layer	Velocity of P-waves in km./sec.	Thickness
1. Sedimentary	$P_s = 2.2\text{–}5.0$	Widely variable.
2. Upper or "Granitic"	$P_g = 5.4\text{–}5.6$	About 10–15 km.
3. Upper Intermediate	$P\ = 6.0\text{–}6.5$	About 15–20 km.
4. Lower Intermediate	$P_Q = 6.8\text{–}7.1$	
5. Lower	$P = 7.8+$	Extending to great depths.

Layer 2 is made up of the acid or sialic rocks of the earlier tables. The composition of Layer 3 is doubtful, but Gutenberg has shown that in North Germany this Layer approaches the surface and takes the place of the "Granitic" Layer; hence it becomes possible that Layer 3 may there be a deeply eroded Pre-Cambrian basement made up of rocks of sialic and basaltic composition such as gneisses and amphibolites. Probably in depth the Upper Intermediate Layer is more dominantly composed of amphibolite or equivalent basaltic material. It is almost certain that Layer 4 is composed of basaltic material—perhaps in the granulite facies—and that it represents the lower part of the world-wide "basaltic layer" which is widely regarded by petrologists as the source of plateau and oceanic basalts and related intrusions. At a depth of 30–40 km. the Lower Layer appears. Its composition is commonly regarded as ultrabasic, though Daly includes at least the upper part of it in his "basaltic" layer—crystalline above and glassy below. My own view is that the Lower Layer is likely to be mainly peridotite, passing down into an ultrabasic and still glassy substratum. Gutenberg and Richter (11) have found seismic evidence consistent with the belief that there is a transition from the crystalline to the glassy state at some depth between 40 and 80 km.

On the basis of this interpretation we should not go far wrong in supposing that the continental crust in certain representative places includes approximately 20 km. of sialic rocks (including sedimentary rocks where present), a similar thickness of basaltic materials, and an unknown balance of peridotitic rocks. The average annual loss of internal heat from the non-volcanic parts of the continents is about 60 calories per sq. cm. Of this amount three quarters is made good by 40 km. of sialic and basaltic materials, leaving less than a quarter to be supplied from the 6,330 km. of the underlying column. If we assume that the whole of this quarter is supplied by radioactivity and that the latter dies out at a depth of 100 km. then the temperature at this depth would be about 1540°C. An exponential distribution of radioactivity that fits the temperature gradient and approximates to the known distribution in the sialic and basaltic layers implies that radioactivity decreases by half every 18 to 20 km. down to the earth's center. The temperature at 100 km. would then be 1500° to 1530°C. At such a depth and temperature peridotite would probably be below its melting point.

There is, however, a serious objection to internal distributions of radioactivity of the two types just assumed. In the first the material of the earth below 100 km. is supposed to be entirely devoid of radio-

activity, while in the second the radioactivity falls off to extremely minute amounts which are equally improbable.

We are completely at a loss to explain how so marked a deficiency in depth could ever have been brought about. If, to begin with, the earth's radioactivity had been uniformly distributed throughout its mass, then the temperature would exceed the melting point at all depths exceeding some 40 or 50 km. Convection would then continue to operate in the glassy substratum until the radioactive elements were so strongly concentrated towards the surface that the substratum had become practically freed from them. Is there any reason for supposing that this condition has yet been achieved? The assumption that so clean a separation can have occurred finds no support in the evidence of geochemistry. Alternatively, it is conceivable that the core and substratum may have been formed from material that was originally free from the radioactive elements, or nearly so, and that the peridotitic, basaltic, and sialic materials of the crust were added later from a source more richly endowed in the radioactive elements. The view that the substratum contains "normal" amounts of the "radioactive" elements but that for some unknown reason they each in turn cease to be radioactive at some critical depth is quite untenable in the light of existing knowledge. Nevertheless, we have at present no means of reaching an unequivocal conclusion. All we can do is to follow up the consequences of two possibilities, one of which must be true:

(A) The substratum may be so nearly free from radioactive elements that the earth can have systematically cooled down in one or other of the ways on which the contraction hypothesis is based.

(B) The radioactivity of the material of the substratum—though of a feeble order compared with that of the crust—may be in excess of the extreme limitation imposed by the requirements of the contraction hypothesis. If so, the temperatures of the interior may still be maintained above the freezing-point.

In alternative B, part of the supply of internal heat must escape sooner or later by processes other than conduction through the crust. Igneous activity is the most spectacular example of such processes. It is important that this function of igneous activity should not be overlooked. In my own early work (14) I began with possibility A and it has been claimed for my treatment that it was satisfactory because it coordinated successfully all the thermal data (Adams, 1 and Jeffreys, 20). I later rejected A, however, precisely because it did not seem to be consistent with the occurrence of certain types of igneous

activity, such as the eruptions of plateau basalts (15). These, after all, represent an important part of the thermal data. It is true that any local increase in the thickness of the radioactive layers of the crust (e.g. in belts of geosynclinal sedimentation and subsequent mountain building) must lead to a considerable rise of temperature in depth, thus favoring the production of magma by refusion and the initiation of vulcanism. But flood-basalts and plateau-basalts have commonly ascended in regions like the Deccan where the crust had already been deeply denuded; that is to say, in regions where the radioactive sialic layer had been thinned. The source of the excess heat necessary to generate magmas in such a geological setting can be looked for only in the substratum, which must therefore have within itself an excess of heat, at least at certain times and places.

The same conclusion may be reached even for the belts of crustal thickening. Radioactive heating in the deep sialic roots of mountain ranges would certainly be competent to bring about the production of granitic magma on a vast scale—but only after the lapse of a hundred million years or more. As granite appears during and immediately after mountain building we have a direct proof that the necessary heat must have come from the substratum. This conclusion is consistent with two other sets of facts: first that contemporaneous vulcanism has commonly occurred during the infilling of the geosynclines from which the mountains afterwards arose; and second that in igneous complexes the usual order of plutonic intrusion is from peridotite through gabbro or diorite, or both, to granodiorite and granite.

It thus appears at the outset that possibility B offers a better chance of accounting for igneous activity than the alternative A. As the latter is based on temperature gradients in regions which have ceased to be volcanic, it cannot be expected to account for volcanic activity. On the other hand, it may be objected that B goes too far since it would seem to require the possibility of vulcanism everywhere and at all times. A reasonable answer is that at any given place the thicknesses of the crustal layers, and the thermal state of the substratum immediately below, may vary from time to time. Variations of both types are necessary consequences of the convection hypothesis and of Joly's hypothesis of thermal cycles.

PHYSICAL BASIS OF THE RIVAL HYPOTHESES

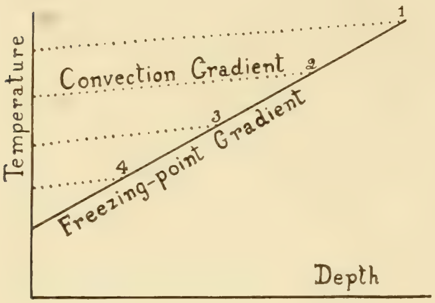
It has already been tacitly assumed that the earth began its thermal history as a fluid globe. It is probable that the first effects of the

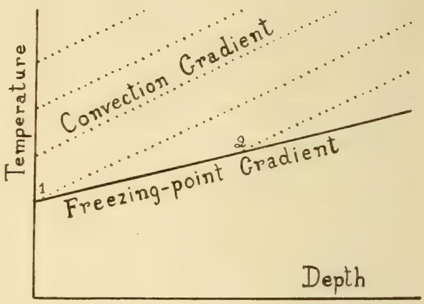
cooling of a gaseous earth (by internal convection and radiation into space) would be the condensation of a succession of liquid phases. Core and substratum would appear first. These would separate in virtue of the immiscibility of their respective liquids. It is to be expected that the magma of the basaltic layers would follow that of peridotite without a break, and that granitic magma would condense next. The lateral discontinuity of the granite layer which is responsible for the existence of continents still offers an unsolved problem. Long after the granite had crystallized, the waters of the hydrosphere would begin to be precipitated. This conception of the early cooling history embodies a possible clue to the reason for the concentration of radioactivity in the crustal layers. It cannot be tested at present because we know nothing of the way in which traces of volatile compounds of uranium and thorium would distribute themselves between liquid and gaseous silicate phases.

The substratum, if produced in this way, would be liquid from the start. It would cool by convection, transmitting its heat to the overlying layers, until somewhere within it the freezing temperature, under the pressure of that depth, was reached. We must next consider whether the freezing temperature would first be reached at the top, at some intermediate depth, or at the bottom.

Convection can continue only so long as a certain downward increase of temperature is exceeded; for convenience this downward increase may be referred to as the convection gradient. The variation of freezing point with pressure corresponds to another gradient which may be referred to as the freezing- (or melting-) point gradient. As shown in Fig. 3., if the freezing-point gradient is steeper than the convection gradient, crystallization must begin at the bottom. If, on the contrary, the convection gradient be the steeper then crystallization begins at the top (Fig. 4). The importance of this distinction was first recognized by Hopkins, but it was left for Dr. L. H. Adams (1) to show that under the pressures corresponding to crustal conditions the freezing-point gradient is the steeper. Such data as we have for silicates suggest that the convection gradient is about 0.3°C. per km. whereas the freezing-point gradient is about 3°C. per km. If this relation continued throughout the thickness of the substratum, then crystallization would first begin at the bottom and a steadily increasing thickness of ultrabasic rock would accumulate until the whole had consolidated. This is certainly one possibility that must be reckoned with.

But here, too, there is an alternative to be considered. Tammann (33) has conjectured from the behaviour of certain hydrous salts that with increase of pressure the melting point of silicate materials may rise to a maximum temperature and then begin to fall again (Fig. 5). If this view were valid, then the curve representing the convection gradient would first touch the freezing-point curve near the peak of





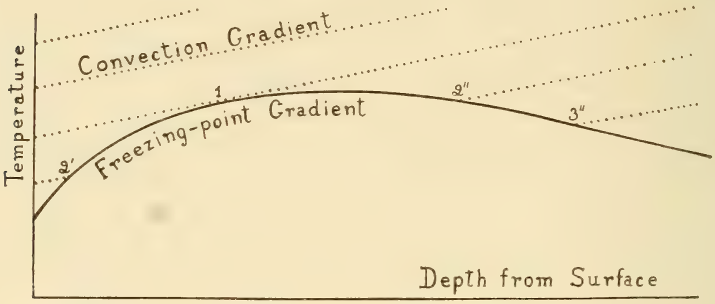


Fig. 3.—Illustrating the course of crystallization in the Substratum from below upwards if the freezing-point gradient be steeper than the convection gradient.

Fig. 4.—Illustrating the course of crystallization in the Substratum from above downwards if the convection gradient be steeper than the freezing-point gradient.

Fig. 5.—Illustrating the beginning of crystallization at some intermediate depth in the Substratum where the convection gradient is tangential to the freezing-point gradient.

the latter, and crystallization would begin at the intermediate depth where the two curves first became tangential. Bridgman (2) has shown, however, that "the evidence * * * seems to be unequivocally against the possibility of a maximum temperature." With hydrous salts the existence of a maximum is a consequence of the effect of pressure on solubility. While this additional effect may, of course, operate in the substratum, which is not likely to be a pure substance, it is improbable that it can be the controlling factor. Bridgman favors the

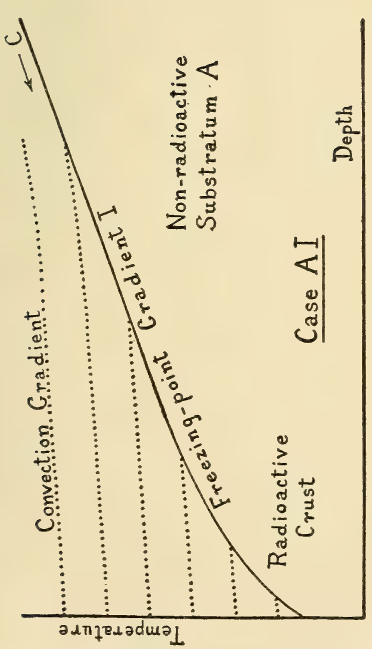


Fig. 6.—Case AI: Thermal conditions appropriate to the "Thermal contraction hypothesis."

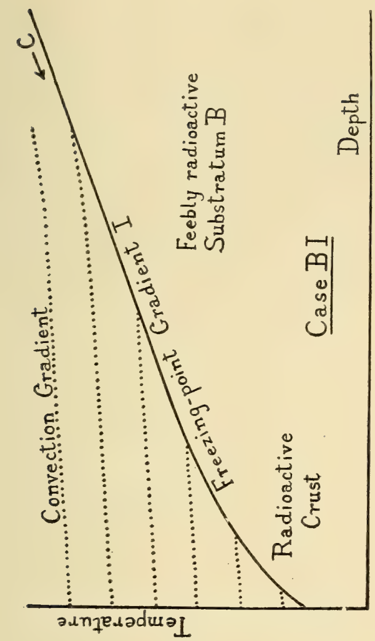


Fig. 8.—Case BI: Thermal conditions appropriate to the "Hypothesis of thermal cycles."

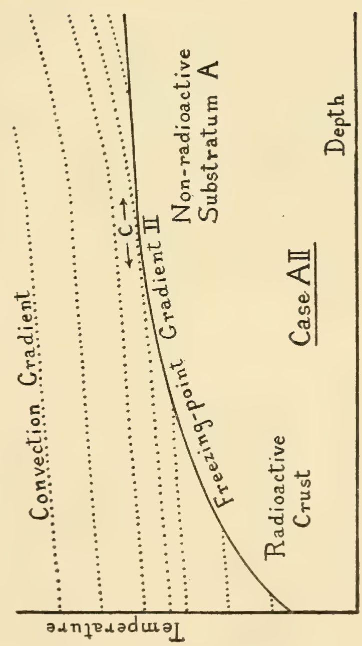


Fig. 7.—Case AII: Thermal conditions appropriate to a modified form of the "Thermal contraction hypothesis."

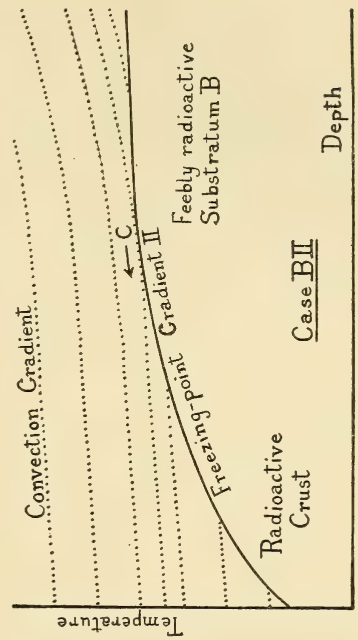


Fig. 9.—Case BII: Thermal conditions appropriate to the "Hypothesis of subcrustal convection currents."

view that the increase of melting point with pressure rises at a continuously decreasing rate. Moreover, since viscosity increases with pressure at a continuously increasing rate, the convection gradient must become steeper with increasing depth. It is thus well within the bounds of probability that the actual relations are like those illustrated in Figs. 7 and 9. The convection gradient being concave upwards and the melting-point curve convex, the two are likely first to meet at an intermediate depth. From this depth crystallization would proceed in both directions, but upwards much more rapidly than downwards; the underlying liquid would continue to circulate until loss of heat through the roof brought convection to an end. This would occur before crystallization was complete and the substratum would then be left as a stagnant glass in which the rate of further crystallization would be negligibly slow. If however, the substratum were only slightly radioactive, convection would continue to be maintained throughout geological time.

As we cannot be sure whether the relations of the convection and freezing-point gradients are such as to initiate crystallization, I, at the bottom of the substratum as in Figs. 6 and 8 or, II, at some intermediate depth as in Figs. 7 and 9, we must follow up the consequences of each alternative. Combining I and II with the two possibilities A and B depending on the distribution of radioactivity in the substratum, we arrive at the four different sets of conditions (AI, AII; BI, BII) represented graphically in Figs. 6–9. Each of these corresponds to one of the theories of the earth that are now on trial. AI and AII provide the physical conditions for alternative forms of the "thermal contraction hypothesis" (23). BI gives the conditions appropriate to the requirements of Joly's "hypothesis of thermal cycles" (26). BII supplies the conditions for the "hypothesis of sub-crustal convection-currents" (16).

AI—THE THERMAL CONTRACTION HYPOTHESIS

Here it is assumed that the sub-crustal material is negligibly radioactive (i.e. that the heat generated within it is insufficient to prevent continuous cooling) and that the freezing-point gradient is steeper than the convection gradient throughout (Fig. 6). Crystallization therefore begins at the bottom of the Lower Layer, presumably producing a peridotite-like rock until an outer residual magma a few tens of kilometres in thickness remains. From this residuum, which must be assumed to contain nearly all the earth's store of radioactive

elements, layers of basaltic and granitic composition crystallize in turn.

The consequences of the contraction hypothesis have been repeatedly discussed, and despite the damaging criticism to which the hypothesis has been exposed, many geologists still retain their faith in its tenets. In 1930, for example, Hobbs (13) expressed his belief that "this view of a shrinking earth is more firmly established today than ever before." On the other hand, Wegener regarded the hypothesis as "completely bankrupt." Both authors omitted to give sound reasons for their contradictory opinions, but at least two sets of considerations seem to me to support Wegener's characteristically sweeping judgment.

As indicated already on p. 176 the thermal limitations of the hypothesis preclude its successful application to the outstanding phenomena of igneous activity. The widespread occurrence of plateau basalts and the appearance of plutonic intrusions during orogenesis seem to be quite inconsistent with the existence of a crystalline interior (19).

Jeffreys has claimed that the compression due to contraction is of the right order to account for mountain-building, and the validity of his claim has been as persistently denied. On both sides, however, the margin of error is so great that a really convincing comparison between theory and fact is at present out of the question (17 and 24). On the other hand, the distribution of mountain-building in time, as tested by the lead-ratios of radioactive minerals, shows that the intervals between the peaks of successive orogenic revolutions have not become systematically longer, as they should have done, according to the hypothesis. Indeed, since Pre-Cambrian time the intervals have become shorter, as the following data clearly show (18).

Orogenesis	Lead-ratios	Intervals
Alpine-Laramide	0.008	
		0.022
Hercynian-Appalachian	0.030	
		0.025
Caledonian-Taconic	*ca.* 0.055	
		0.030
Upper Pre-Cambrian	0.085	
		0.045[a]
End of Middle Pre-Cambrian	0.130	

[a] It is possible that this interval represents two intervals of 0.025 and 0.020 divided by the Killarnean orogenesis with a lead-ratio of 0.110.

This apparent speeding-up of the earth's orogenic activities is demonstrated in detail by Figs. 10 and 11. In Fig. 10 a first approximation to a geological time-scale is provided by plotting lead-ratios against maximum thicknesses of sediments from the Cambrian onwards. The steepening of the curve as the present is approached accords with the findings of Barrell and Schuchert to the effect that rates of denudation and sedimentation have steadily increased since Pre-Cambrian time. In Fig. 11 the orogenic episodes recognised by Stille are plotted against the time-scale. The results show at a glance that there has been a remarkable acceleration of activity.

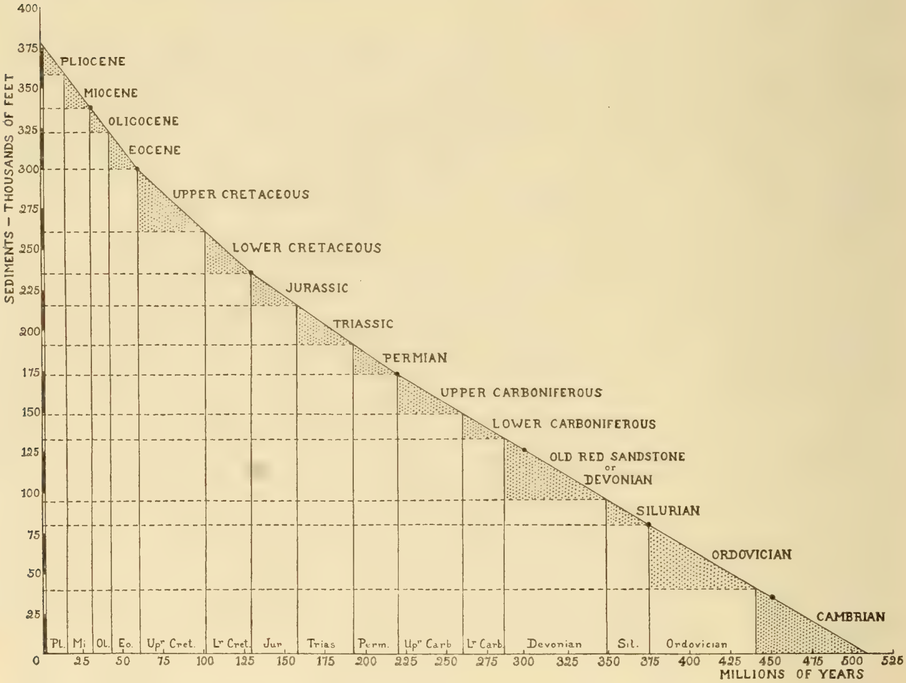


Fig. 10.—An approximate geological time-scale based on lead-ratios (plotted as abscissae) and maximum thicknesses of sediments (plotted as ordinates).

The contraction theory implies an ageing earth that should now have reached senility. The fact is that during the Tertiary period the earth was more vigorous in her behaviour than ever before during at least the last thousand million years. Many other objections to the hypothesis could be urged, but those here given seem to be ample to justify its rejection.

AII—MODIFIED FORM OF THE THERMAL CONTRACTION HYPOTHESIS

In this case (Fig. 7) the assumed distribution of radioactivity is that of AI, but the two gradients are regarded as becoming tangential at some intermediate depth. Crystallization begins at this depth and proceeds upwards as in AI. Crystallization—or possibly consolidation into the durovitreous state—also proceeds downwards into the underlying zone of convection so long as the heat brought up can be carried away by conduction through the crust. The underlying convective zone slowly thins and dies out by downward thickening of the crust as loss of heat reduces the gradient below the critical value. The bulk of the substratum is then left as a stagnant glass in which downward crystallization very slowly proceeds. The period required for complete crystallization would be very long compared with geological time. This form of the contraction hypothesis implies that the substratum was practically devoid of radioactivity from the start, since the cooling process in itself provides no mechanism for concentrating any originally dispersed radioactivity towards the surface.

Jeffreys finds that on this hypothesis crystallization may now have proceeded to a depth of a few hundred kilometres. As compared with AI a little more contraction may be available because of the volume change attending crystallization or the passage from the liquevitreous to the durovitreous state. On the other hand the gradient due to the

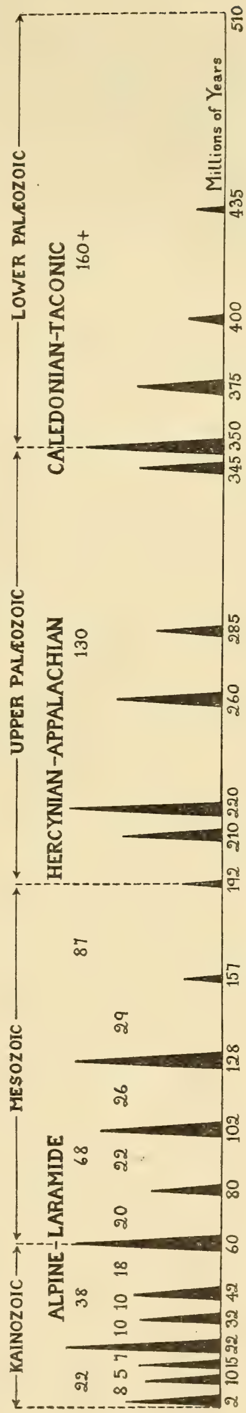


Fig. 11.—Orogenic episodes (after Stille) of Post-Cambrian time plotted on the time-scale of Fig. 10. An assessment of the relative intensities of the respective orogenies is roughly indicated by the heights of the black triangles.

increase of freezing-point with depth—which gives rise to an outflow of heat at all depths that have crystallized—is less steep than in AI, and gives a heat flow through only a shallow depth instead of all through the Earth. In this respect, therefore, there is less contraction, and on the whole AII seems to be even less capable of matching the facts than AI. Indeed, in his latest work Jeffreys clearly shows his preference for AI (25).

BI—HYPOTHESIS OF THERMAL CYCLES

The substratum is assumed to be slightly radioactive, sufficiently so for the heat generated to prevent permanent crystallization. The two assumed gradients being as in AI, crystallization begins at the bottom and proceeds towards the surface (Fig. 8). Once convection has ceased, heat is generated at all depths below a certain critical level (near the base of the basaltic layer) faster than it can be carried off by conduction. This excess of heat supplies latent heat and promotes re-fusion. Sooner or later the growing threads of fluid unite and liberate crystal individuals or aggregates which sink, unless the viscosity is sufficiently high to prevent them from doing so at any effective rate. A layer of magma thus accumulates and rises upwards, increasing in thickness as it ascends. Convection recommences within this layer, and accelerates the upward migration until the base of the basaltic layer is reached. Re-fusion of the basaltic material then proceeds. At this stage the temperature at the top of the zone of fusion is below the freezing-point of peridotite and the peridotite magma gradually solidifies as the basaltic layer is fused. Finally, under the continents, much of the granitic layer may become fused in turn before the overlying crust becomes sufficiently thin to carry off the excess of heat and bring about consolidation. During the later stages, igneous activity is inevitable in both continental and oceanic regions. Essentially the cycle consists of the ascent of a wave of fusion from great depths, thickening until it comes under the cooling influence of the surface, and then dying out as the surface is closely approached. Before the first cycle is completed another will have begun in the depths of the substratum. The earth's history is thus thought to be controlled by a succession of "thermal cycles."

It is obvious that if the maximum depth ever reached by a zone of fusion were to exceed a certain thickness (of the order of a few tens of kilometres,) it would fail to die out before breaking clean through to the surface. As this has not happened on a regional scale within

known geological history there is here a clear indication that the hypothesis cannot legitimately invoke waves of fusion of more than relatively small amplitude. This limitation implies an average radioactivity in the substratum of a much lower order than that of the crust (1/100th or less).

It was assumed in the above statement that the viscosity of the substratum was not too high to prevent the effectual sinking of crystals. Actually, however, the viscosity is extremely high; Jeffreys finds a mean value exceeding 5×10^{20} c.g.s. from the 14-monthly variation of latitude. Under such conditions crystals could not sink through any appreciable distance during geological time. Thus the conditions favourable to thermal cycles would seem to be limited to within 100 km. or so from the surface. But as fusion would nevertheless steadily proceed throughout the substratum, successive cycles or groups of cycles would involve ever-increasing depths, until finally a wave of fusion would rise of such amplitude that the whole crust would be engulfed, and in part remelted. Accepting the premises, it is by no means inconceivable that such a fate may overtake the earth at some remotely future time. The danger arises from the conditions implied by the hypothesis under consideration; first, the rising convection currents maintain temperatures at the top that are well above the melting-point of the materials of the roof; and second, the heat represented by the excess of temperature over the melting point, and the latent heat of the material of the wave of fusion, have both to escape through to the surface before reconsolidation can occur.

The advantages of Joly's hypothesis are many, but unfortunately they are both dangerous and incomplete. Each period of consolidation corresponds to one of crustal contraction and mountain-building, and in this respect the hypothesis is more satisfactory than the traditional contraction hypothesis, as it provides for repeated consolidations, each time beginning afresh from conditions of fusion. Obviously, there is ample opportunity for igneous activity on the most extravagant scale. Marine transgressions and recessions are a necessary consequence of thermal cycles. Partial foundering of the lands and their invasion by epeiric seas take place during conditions of widespread fusion, followed by recovery and withdrawal of the seas during the succeeding phase of contraction and orogenesis.

Jeffreys has vigorously attacked the hypothesis on physical grounds (21 and 22). Joly requires a westerly tidal drift of the crust to drag the ocean floors over the magmatic layer and so permit the excess sub-continental heat to be discharged through the chilled and atten-

uated oceanic part of the crust. Jeffreys gives good reasons for thinking that this drift could not occur at the required rate. On the other hand, J. H. J. Poole (31) has developed a form of the hypothesis in which tidal drift does not appear. McCarthy (29) has pointed out that rapid loss of heat through the oceanic floors would involve abnormal heating of the oceanic waters, and this consideration undoubtedly limits the application of the hypothesis to a very thin layer of fusion. A serious objection to the hypothesis in its ideal symmetrical form is its implication that world-wide crustal tension (during fusion and expansion) has alternated in time with world-wide compression (during consolidation and contraction). The testimony of geology is that compression seems always to have been more or less active somewhere or other in the world, periodicity being a matter of climaxes in particular regions heralded by crescendos and followed by diminuendos. Moreover, tensional phenomena have often been contemporaneous with compressional phenomena elsewhere. It might be possible to modify the hypothesis so that it would become consistent with these phenomena, but to do so would necessitate the discovery of a non-uniform distribution of radioactivity in the crust on a regional scale and to an extent that the evidence so far collected fails to foreshadow. Like the thermal contraction hypothesis, this one equally fails to account for the development of geosynclines, the subsiding areas of long-continued sedimentation that formed the gathering ground of the formations out of which long belts of mountain ranges were destined to be built. It must also be pointed out that Joly's hypothesis is at variance with the rate of the apparent speeding-up of geological activities to which reference has already been made. Certainly successive cycles would be of increasing intensity if each wave arose from a greater depth than the previous one, but if so the time intervals between them would become systematically longer.

Although it seems highly improbable that the hypothesis of thermal cycles can by itself express the earth's thermal history, it would be rash to deny its applicability to certain of the problems of crustal thermodynamics. The formation, ascent, and consolidation of magmas and consequent isostatic changes of level seem to fall within the scope of its mechanism, but on a scale less grandiose than that visualized by its author.

BII—HYPOTHESIS OF SUB-CRUSTAL CONVECTION CURRENTS

Here it is assumed that the gradient in the convecting layer becomes tangential to the freezing point gradient at some intermediate

depth (Fig. 9). Tangential conditions are likely to be closely approached through a zone of considerable thickness. Crystallization begins in this zone and proceeds upwards until a crust is formed over a convecting interior. Under these conditions the rising convection currents reach the overlying roof at or near the temperature of the melting point of the roof materials. Moreover, the latent heat of the substratum below the level of tangency is not liberated by crystallization and does not escape through the crust, since crystallization tends to occur only at and above the level of tangency and not at the bottom of the substratum. Only the latent heat of material fused *above* the level of tangency has to pass through the crust. From this cause there is therefore no danger of catastrophic crustal fusion on a worldwide scale after the crust has once formed. The substratum remains in a glassy state (liquevitreous of Jeffreys), characterized by rigidity, high viscosity, no permanent strength, and sufficient radioactivity to maintain a slow but ever-changing convective circulation.

It is easy to see that the zone of tangency must lie beneath the basaltic layers. It cannot be in the latter because of the marked fall of melting-point in passing upwards from peridotitic to basaltic material. On the other hand, if the zone of tangency were deep in the peridotitic layer, the crust would be too thick to carry off by conduction the heat brought up by rising convection currents. The peridotitic layer would then heat up, and its temperature gradient would steepen, until the actual zone of tangency migrated to a higher level. This implies partial fusion of the lower part of the peridotitic layer and the generation of successive waves of magma which would ascend into the crust as in the Joly cycles. The evidence of igneous activity indicates that such waves are relatively thin, whence it follows that the shell of material fused by the ascent of the zone of tangency must itself be thin. An average depth for the zone of tangency between 40 and 80 km. would seem to coordinate all the relevant data. Such a depth corresponds first with that suggested by Gutenberg and Richter (11) for the passage from the crystalline to the glassy state; and second, with the thermal necessity that conditions of fusion must normally reach a level some distance above the depth where the melting point would be attained in virtue of the radioactivity of the overlying material.

The above discussion indicates that variations in the thickness and radioactivity of the crust, together with changes in the temperature gradient of the substratum, may combine to extend very considerably the range of the shell subject to refusion. For this reason the condi-

tions which determine whether the substratum gains on the crust by upward melting or the crust gains on the substratum by downward crystallization are likely to vary from place to place and from time to time.

To prevent convection in a layer extending far down towards the core a viscosity exceeding 10^{26} would be necessary. As we have good evidence that the actual viscosity is well below this limit there is no physical improbability about internal convection. Vertical currents ascend in certain places and on reaching the top the material promotes sub-crustal fusion and spreads out laterally, flowing horizontally to the neighboring descending currents. The horizontal flow is likely to exercise a powerful viscous drag on the lower levels of the crust, throwing the latter into tension where the currents diverge and into compression where they converge (Figs. 12 and 13). If the distance between ascending and descending currents be of continental dimensions then the drag due to horizontal flow may produce continental displacements, with distension behind and mountain-building in front. Material from the substratum ascends into the distended area, where it cools, and differentiates, while heavy compressed crustal material (eclogite from the basaltic layers) is dragged down with the descending currents.

Excess heat from the substratum is thus discharged (a) by cooling due to thinning of the crust and consequent development of basins,

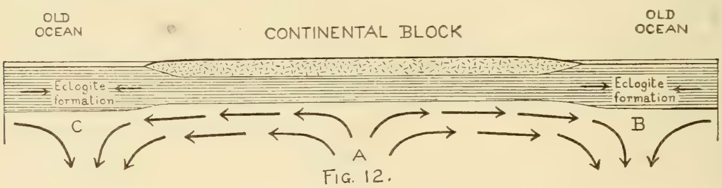


FIG. 12.

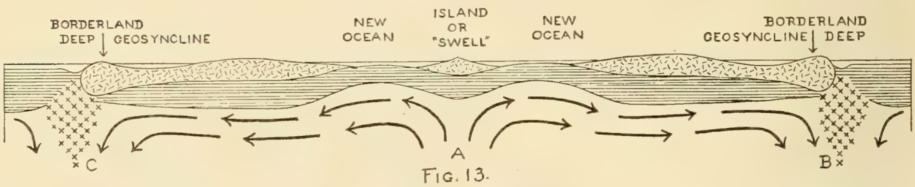


FIG. 13.

Fig. 12.—Sub-continental circulation in the Substratum with eclogite formation from the basaltic rocks of the Intermediate Layer above B and C where the sub-continental currents meet sub-oceanic currents and turn down. Upper "Granitic" Layer, dotted. Intermediate Layer (gabbro, amphibolite, basic granulite, etc.), line-shaded. Substratum, unshaded.

Fig. 13.—Distension of the continental block on each side of A with formation of new ocean floors from rising basaltic magma. The front parts of the advancing continental blocks are thickened into mountainous borderlands with oceanic deeps in the adjoining ocean floor due to the accumulation of eclogite at B and C.

geosynclines or ocean floors over the sites of ascending currents; (*b*) by the heating-up and remelting of crustal materials carried down in descending currents; and (*c*) by igneous activity of all kinds.

The convection hypothesis has the advantage over its rivals that it naturally and inevitably provides for simultaneous tension and compression. Good examples of this are the opening of the Uralian geosyncline at the same time as the crumpling up of the Caledonian mountains of Scandinavia, and the formation of the North Atlantic while the Rockies, Sierras, and Coast Ranges of Western North America were being formed.

According to the convection hypothesis, we should expect mountains to be formed where two series of approaching currents turn down and so compress the overlying layers of the crust (Figs. 12 and 13). Experiments by Bull (5) have shown that this kind of mechanism provides the only method yet devised for successfully imitating nappe-structures like those of the Alps. While the mountains are being built from sialic materials, the underlying basaltic material is dynamically metamorphosed into the dense eclogite facies and is sucked down by the downward-flowing currents. After the folding, some of this material will in many places remain beneath the orogenic belt, and its inevitable fusion must tend to heave up the overlying mountain range. Where it happens, however, that the fused material is squeezed out sideways, the mountain chain will break down and parts of it may even subside beneath sea-level. Other parts of a folded belt may never have risen above the sea.

Jeffreys has pointed out that many old peneplained mountain ranges are still represented by tracts of folded sediments, despite the fact that if they had been worn down to this extreme degree by denudation alone, all the sediments and much of the underlying granitic layer should have been removed (23, p. 296). He suggests that these tracts have in part been lowered by "outflow of matter from the intermediate layer, with compensating inflow in the lower layer." Such an effect would be brought about equally well by the passage of a sub-crustal current, for the latter would tend to "erode" the roots, carrying away the corroded material in the direction of movement, just as ice-sheets have ground down the protuberances of the land surface beneath them and spread out the debris in the lowlands beyond.

The distribution of the latest of the earth's mountain systems (Figs. 14 and 15) shows that they form interrupted rings surrounding the great northern land masses of N. America and Eurasia (known

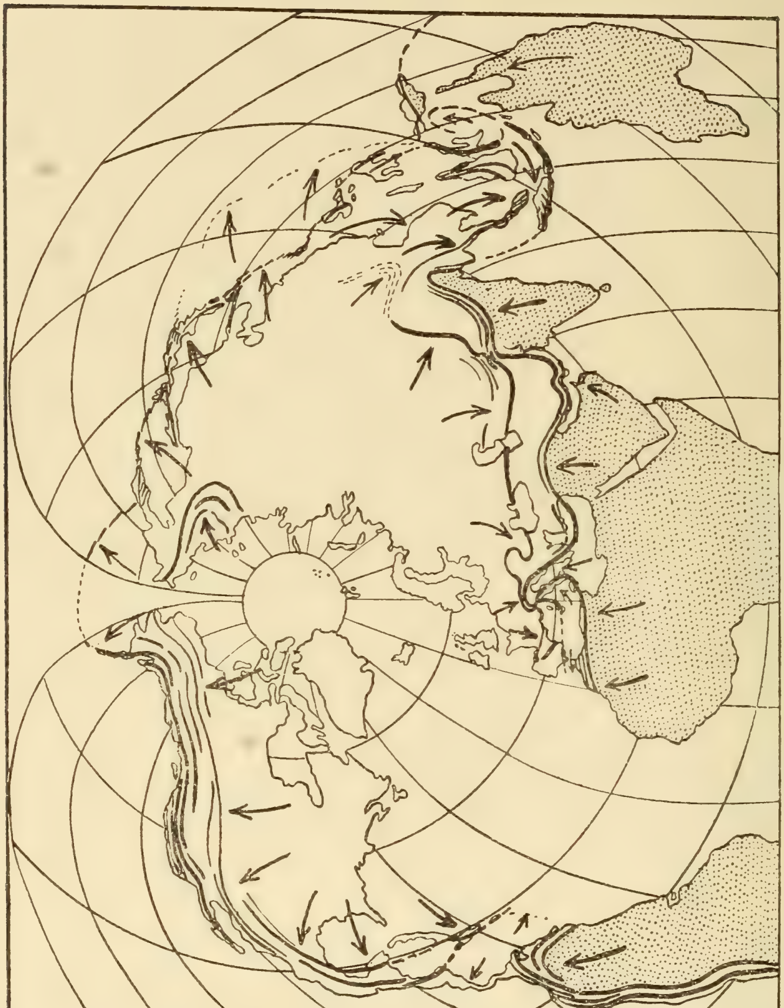


Fig. 14.—Orogenic ring peripheral to Laurasia with continental movements directed outwards towards the Pacific and the Tethys. (The adjoining blocks of Gondwanaland are dotted.) Scale: 1: 170×10⁶.

as Laurasia) and the southern lands of S. America, Africa, India, Australia, and Antarctica (known as Gondwanaland). Each great land mass seems to have been the centre of a system of currents directed outwards towards the Pacific and towards the former Mediterranean—the Tethys—that lay between Gondwanaland and Laurasia. Peripheral ranges of mountains were raised up in front of each advancing continental block—and in some places, such as the East and West Indies, the process seems still to be in operation. Earthquakes and volcanoes are specially numerous in and adjacent to these peripheral rings of crustal instability.

Fig. 15.—Orogenic "ring" peripheral to Gondwanaland (dotted) with continental movements directed towards the Pacific and the Tethys. Scale: 1: 210×10^6.

The formation of eclogite in front of active mountain ranges is strongly suggested by the oceanic deeps of the western margins of the Pacific. Here, too, lie the epicentres of many deep earthquakes that have originated from foci hundreds of kilometres below the surface (35). If these deep-seated disturbances are not in some way a result of currents operating far down in the zone of flowage where great masses of eclogite may be fractured as their strength is overcome, it is difficult to conceive an alternative mechanism that could be responsible for them.

The action of sub-continental currents directed towards the Pacific shores may be inferred from the echelon structure of the island festoons of Asia (34), and from the great and geologically rapid uplifts of the outer zones of many growing island-arcs (Hobbs, 12). Evidence of a different sort, suggesting the action of a sub-Pacific current, is forthcoming from a comparative study of certain coral reefs in the Fiji group made by W. M. Davis. It will suffice here to quote a single sentence from the paper referred to (8): "The changes of level in the several belts all appear to be caused by the slow westward migration of a broad and low ocean-floor anticline, preceded and followed by shallow ocean-floor synclines." Substratum currents acting on the under surface of the crust may be expected to produce migrating sub-crustal wave-forms which would be mirrored above by migrating anticlines and synclines of the kind discovered by Davis.

The remarkable belt of negative anomalies of gravity recently discovered by Meinesz in the East Indian Archipelago (30) may also be a symptom of sub-crustal currents. A powerful downward drag seems necessary to account for the astonishing departure from isostatic equilibrium that has been revealed (17). Other anomalies, however, such as those which imply that the equator of the geoid may be slightly elliptical instead of circular, have been used by Jeffreys in support of the view that the substratum has sufficient strength to withstand considerable regional departures from isostatic equilibrium (23, p. 222). If the substratum has strength, its viscosity is infinite until the strength has been overcome, and convection currents would then be impossible. The objection is not final, however, for its acceptance raises in turn a fresh difficulty. If Africa, for example, stands high to an extent implying a slight bulge in the equator, then its tendency should be to sink; yet actually its tendency has been, and geologically speaking, still is, to rise. I have therefore suggested the alternative interpretation that the "bulge" may be an

expression of some dynamic process operating in the substratum at a rate slightly in advance of that of isostatic re-adjustment (16, p. 576). There is here a difference of opinion that should be amenable to mathematical treatment and decision.

Turning to evidence of a very different kind, it is worthy of notice that the maintenance and secular variations of the earth's magnetic field are regarded by Chapman (7) as possible consequences of a deep-seated internal circulation of material. Another suggestive indication of flowage in the substratum is provided by the mysterious fluctuations in the earth's rate of rotation which have been studied by de Sitter (9) and Brown (3). De Sitter points out that the sudden shortening of the day which happened in 1918 could have been produced "by a very slight adjustment of the layers of equal density in the inside of the earth, of which the effect on the dimensions of the outer surface need not exceed a fraction of a millimeter." The significance of this statement is best realised by considering that "if the whole of the Central Asian Highlands from the Himalaya to the Kwen Lun Mountains (both included) had at that time been sunk into the earth, their mean height being reduced to sea-level, the resulting shortening of the day would have been only one fourth of what is required." We have in such remarkable time-changes an indubitable indication of deep-seated widespread movements within the earth—movements which must, moreover, arise from causes originating inside the earth, quite independently of any external cause due to sun, moon, or stars.

So far, little has been said about continental drift, and space does not allow of any critical discussion of the evidence for or against it. It may be said, however, that on the thermal contraction hypothesis continental drift is manifestly impossible, whereas on the convection hypothesis a certain amount of drift is inevitable mechanically; it serves, moreover, to provide a means of escape for the heat carried up to the crust by the more powerful ascending currents. The convection process seems also to be intimately related to the acceleration of geological activities since Pre-Cambrian times, and to the cognate fact that continental drift does not appear to have operated on a considerable scale until after the Hercynian orogenesis. If eclogite is carried down by descending currents into the substratum, then some of the basaltic material must be dissolved in the substratum which, in consequence, becomes locally enriched in the radioactive elements. The tendency to circulate in convection currents should, therefore, have become more marked with the advance of geological time, and this would necessarily have provided more earth movement, more

igneous activity, and in general more intense manifestations of energy in every direction. The explanation suggested implies that the radioactive layer was not concentrated from the interior, as generally assumed, but that conversely, the interior has been steadily gaining radioactivity at the expense of the lower levels of the crust. If so, the earth has an exciting geological history in store.

Although the hypothesis invoking sub-crustal convection currents cannot be regarded as established, it is encouraging to find that it is consistent with a wide range of geological and geophysical data. Moreover, it is by no means independent of the best features of the other hypotheses. It requires the local operation of thermal cycles within the crust, and it necessarily involves contraction in regions where crustal cooling takes place. It is sufficiently complex to match the astonishing complexities of geological history, and sufficiently startling to stimulate research in many new directions. And therein lies its chief merit, whether it fails or succeeds. Jeffreys (24) can find nothing inherently impossible in the hypothesis, but he thinks that "its validity would be a remarkable accident." I agree; but then I think the earth is no less a remarkable accident. It is impossible to be a geologist without realising that—in the dim light of the knowledge we have so far gained—the earth we live on is a strange and most improbable planet.

Of the figures which illustrate this paper Figs. 1–13 have been drawn for me by my friend Miss Doris L. Reynolds and in conclusion I wish to record my grateful thanks for her generous cooperation. The two maps, Figs. 14 and 15, are reproduced from an earlier paper (16) by permission of the Council of the Geological Society of Glasgow.

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CRYSTALLOGRAPHY.—*The crystal structure of tenorite (cupric oxide).*[1] G. Tunell, E. Posnjak, and C. J. Ksanda, Geophysical Laboratory, Carnegie Institution of Washington.

The monoclinic symmetry of the thin tenorite crystals from Vesuvius has been established by Tunell and Posnjak (details not yet published); the proof consisted in the demonstration that the extinction position remained stationary when the crystal was rotated

[1] Received February 28, 1933.

around the b axis. The b axis also bisects the angle formed by the traces of the two perfect cleavage planes.

The monoclinic symmetry of an artificial single crystal of cupric oxide prepared for this crystallographic study was established independently by x-ray analysis. The identity of artificial cupric oxide and the thin tenorite crystals from Vesuvius was established by a number of powder photographs. The unit cell dimensions a_0, b_0, c_0, and β of artificial cupric oxide were calculated from measurements made on rotation and Weissenberg pictures. Powder and rotation photographs were taken with Mo-radiation and also with Cu-radiation. Weissenberg pictures of the equator and first and second layer-lines were taken with Cu-radiation and were analyzed by the construction of Schneider.[2] With the Weissenberg x-ray goniometer the direction of the normal to each atomic plane of a crystal of any system and also the spacing along each normal can be uniquely and rigorously determined even if the crystal has no external faces; the unit cell dimensions a_0, b_0, c_0, and β of a monoclinic crystal can thus be calculated. The dimensions of the unit cell calculated from the measurements with Mo-radiation are $a_0 = 4.66$Å, $b_0 = 3.40$Å, $c_0 = 5.09$Å, all $\pm .02$Å, $\beta = 99°30' \pm 30'$; slightly more accurate measurements have been made with Cu-radiation and the unit cell dimensions calculated from them will be given in the final report. The dimensions given yield an axial ratio that agrees well with that calculated by Scacchi[3] from measurements made by Jenzsch[4] with a reflection goniometer on crystals formed in a smelter-hearth near a flue at Freiberg in roasting copper matte with sodium chloride, and also with the axial ratio of Story-Maskelyne.[5] Our x-ray measurements are also in good agreement with measurements made by us on a Goldschmidt reflection goniometer, as well as with the older measurements, as is shown in the following table.

The atomic structure was deduced from the relative intensities of the diffraction lines and spots, and the parameter was determined. Thus a complete solution was obtained by means of the Weissenberg x-ray goniometer. By comparing a list of the planes affording diffraction spots with the "Röntgenographische Auslöschungstabellen" of K. Herrmann[6] we found that a perfect correspondence exists with the

[2] Zeit. f. Krist., **69**: 41. 1928.

[3] Contribuzioni mineralogiche per servire alla storia dell' incendio vesuviano del mese di Aprile 1872, p. 12, Atti d. R. Accad. d. Sc. fis. e. mat. Napoli. **6**: 1875.

[4] Poggendorff's Ann. d. Phys. u. Chem., **107**: 647. 1859.

[5] Verh. Petersb. Min. Ges., **1**: 147. 1866.

[6] Zeit. f. Krist., **68**: 288. 1928.

TABLE 1. PRISM ANGLE OF TENORITE ($f \wedge f$).

Jenzsch (Reflection Goniometer)	$72°57\frac{1}{3}'$
Story-Maskelyne (Reflection Goniometer)	$73°18'$
Tunell, Posnjak, Ksanda (Reflection Goniometer)	$72°59'$
Tunell, Posnjak, Ksanda (X-ray Goniometer)	$72°51' \pm 30'$

theoretical extinctions of the space groups, $C2/c$ and Cc (C_{2h}^6 and C_s^4), the extinctions of these two space groups being identical. A decision between these two space groups is of course not possible by a consideration of extinctions alone. However, the intensities of the diffraction spots point strongly to an arrangement of the atoms of cupric oxide in special positions of $C2/c$ (C_{2h}^6), a conclusion strengthened by the fact that the crystal habit observed in the two preceding studies with the reflection goniometer, those of Jenzsch and of Story-Maskelyne, as well as in our own study, has the full holohedral symmetry of the monoclinic system, that is, the symmetry of the normal class (C_{2h}).

The arrangement of the atoms in tenorite that reproduces the observed intensities is one in which the copper atoms occupy centers of symmetry and the oxygen atoms are situated on axes of symmetry. The coordinates of the copper atoms are $\frac{1}{4}, \frac{1}{4}, 0; \frac{3}{4}, \frac{3}{4}, 0; \frac{3}{4}, \frac{1}{4}, \frac{1}{2}; \frac{1}{4}, \frac{3}{4}, \frac{1}{2}$; the coordinates of the oxygen atoms are $0, n, \frac{3}{4}; 0, \bar{n}, \frac{1}{4}; \frac{1}{2}, n+\frac{1}{2}, \frac{3}{4}; \frac{1}{2}, \frac{1}{2}-n, \frac{1}{4}$, where n, the parameter along the symmetry axis, has approximately the value, -0.08. The atoms are thus arranged in a four coordination, each oxygen being surrounded at approximately equal distances by four copper atoms on the corners of a non-equilateral tetrahedron and each copper atom being surrounded at approximately equal distances by four oxygens lying in a plane at the corners of a rectangle. The interatomic distance Cu-O is 1.9^+ Å, a value in good agreement with that predicted by M. L. Huggins for electron-pair bonded copper and oxygen in a four coordination. A decision as to whether the particles of cupric oxide are atoms or ions is not possible from the interatomic distance alone, however, since this distance is also in good agreement with that calculated, with the aid of V. M. Goldschmidt's curves of ionic radii, on the assumption that the crystal is composed of cupric and oxygen ions in a four coordination.

The structure of tenorite previously described by Niggli[7] was based on powder photographs only and is not correct. The conclusion of Kalkowsky[8] and of Niggli that tenorite is triclinic, pseudomonoclinic, is without foundation in experiment, and is erroneous. Niggli was apparently misled by the erroneous work of Kalkowsky; there is also the further extenuating circumstance for Niggli's failure to arrive at the correct structure that his conclusion was based on some very old powder photographs on which the crucial lines were probably missing. These lines are readily brought out, however, by the powerful radiation available today.

BOTANY.—*Two new grasses of the genus* Stipa *from Western United States.*[1] JASON R. SWALLEN, Bureau of Plant Industry.

Stipa latiglumis Swallen sp. nov.

Perennis; culmi graciles, erecti, 50–110 cm. alti, strigosi; vaginae pubescentes internodiis breviores; laminae planae 5–25 cm. longae, usque ad 3 mm. latae, supra pilosae, subtus glabrae; ligula 1–4 mm. longa; panicula 15–30 cm. longa, ramis gracilibus appressis usque ad 10 cm. longis; glumae subaequales 12–15 mm. longae, 3 mm. latae, firmae, acutae vel acuminatae, 3-nerves; lemma 8–9 mm. longum, dense pilosum, callo 1 mm. longo pungenti, arista bigeniculata plumosa.

Fig. 1

Fig. 2

Fig. 1.—*Stipa latiglumis,* floret ×5 dia. and nat. size. From type specimen.
Fig. 2.—*Stipa lobata,* floret ×5 dia. and nat. size; summit of floret showing lobe ×10 dia. From type specimen.

[7] Zeit. f. Krist., **57**: 253. 1922.
[8] Zeit. Kryst. Min., **3**: 279. 1879.
[1] Received January 17, 1933.

Perennial; culms slender, erect, 50–110 cm. tall, strigose below, nearly smooth above; sheaths, at least the lower, pubescent, shorter than the internodes; blades flat or loosely involute, 5–25 cm. long, not more than 3 mm. wide, hairy on the upper surface, smooth on the lower; ligule membranaceous 1–4 mm. long; panicles loosely flowered, 15–30 cm. long, hairy in the axils, the branches distant, slender, the lower ones as much as 10 cm. long; glumes about equal, 12–15 mm. long, 1.5 mm. broad from keel to margin, firm, rather abruptly acute or acuminate, 3-nerved, tinged with purple; lemmas 8–9 mm. long, densely hairy, the sharp callus 1 mm. long, the awn 3.5–4.5 cm. long, twice bent, the first two segments twisted, plumose, the third straight, scabrous, or pubescent below.

Type in the U. S. National Herbarium no. 992334, collected at Camp Lost Arrow, Yosemite Valley, California, altitude 4,000–4,500 feet, June 22, 1911, by LeRoy Abrams (no. 4469).

Specimens of *Stipa latiglumis* have been referred previously to *S. californica* Merr. & Davy and to *Stipa elmeri* Piper & Brodie. From the first it differs in having pubescent culms and sheaths, and longer, more plumose awns, from the second in the usually less dense pubescence, and from both in having firmer, broader, purplish glumes and longer lemmas. In *S. californica* the culms and sheaths are glabrous and the awns are 2.5–3.5 cm. long; the pubescence of *S. elmeri* is conspicuous without a lens, but that of *S. latiglumis* is scarcely evident except with a lens; and in both *S. californica* and *S. elmeri* the glumes are thin, pale, and not more than 1 mm. wide from keel to margin, and the lemmas are only 6–7 mm. long.

Central California, at medium altitudes.

Yosemite Valley: *Bolander* 6099, *Abrams* 4469, *Jepson* 4280; Dunlap to Millwood, *Griffiths* 4680.

Stipa lobata Swallen, sp. nov.

Perennis; culmi dense caespitosi, erecti, 35–85 cm. alti, glabri, infra paniculam scaberuli; vaginae internodiis longiores, scaberulae, marginibus pilosis; laminae basi planae, attenuatae, usque ad 50 cm. longae, basi 1–4 mm. latae, supra scabrae, subtus laeves; ligula 0.5 mm. longa; panicula 10–18 cm. longa, ramis appressis multifloris; glumae subaequales, acuminatae, 9–10 mm., raro usque ad 12 mm., longae, 3-nerves; lemma 6 mm. longum, dense pilosum, lobatum, callo obtuso; arista bigeniculata, 12–16 mm. longa, hispida.

Perennial; culms densely tufted, erect, 35–85 cm. tall, glabrous, scaberulous below the panicle; sheaths longer than the internodes, or the upper ones shorter, scaberulous, the margins sparsely pilose; blades flat or loosely folded toward the base, long-attenuate to a fine involute tip, as much as 50 cm. long, 1–4 mm. wide at the base, scabrous on the upper surface, nearly smooth beneath; ligule less than 0.5 mm. long; panicles 10–18 cm. long, the branches appressed, rarely more than 5 cm. long, several-flowered; glumes subequal, or the first a little longer, acuminate, 9–10 mm., the second sometimes as much as 12 mm., long, both 3-nerved, scabrous; lemma 6 mm. long, brownish, evenly densely hairy, the hairs 1–2 mm. long, the callus very short and blunt, the summit 2-lobed, the lobes 0.8–1.5 mm. long, awned from between the lobes, the awn 12–16 mm. long, twice bent, the first two segments twisted, appressed hispid, the third segment straight, scabrous.

Type in the U. S. National Herbarium no. 905722, collected on a rocky hill, Ranger Station, Queen, Guadalupe Mountains, New Mexico, altitude

6,000–7,000 feet, September 3–6, 1915, by A. S. Hitchcock (Amer. Gr. Nat. Herb. no. 819).

This species has been referred to *Stipa scribneri* Vasey, but differs in having shorter, nearly equal glumes, which are prominently scabrous, shorter awns, and shorter, lobed lemmas, which are evenly hairy all over. In *S. scribneri* the glumes are unequal, the first about 10 mm., the second 15 mm. long, scaberulous, the awns are 17–20 mm., the lemmas are 7–9 mm. long, the lobes of which are less than 0.5 mm. long, and the hairs at the summit are 2 mm. long, conspicuously longer than those on the body.

Rocky hills at medium altitudes, southern Texas and New Mexico.

TEXAS: Chisos Mountains, *Moore & Steyermark* 3362; Guadalupe Mountains, *Moore & Steyermark* 3638; without locality, *Nealley*.

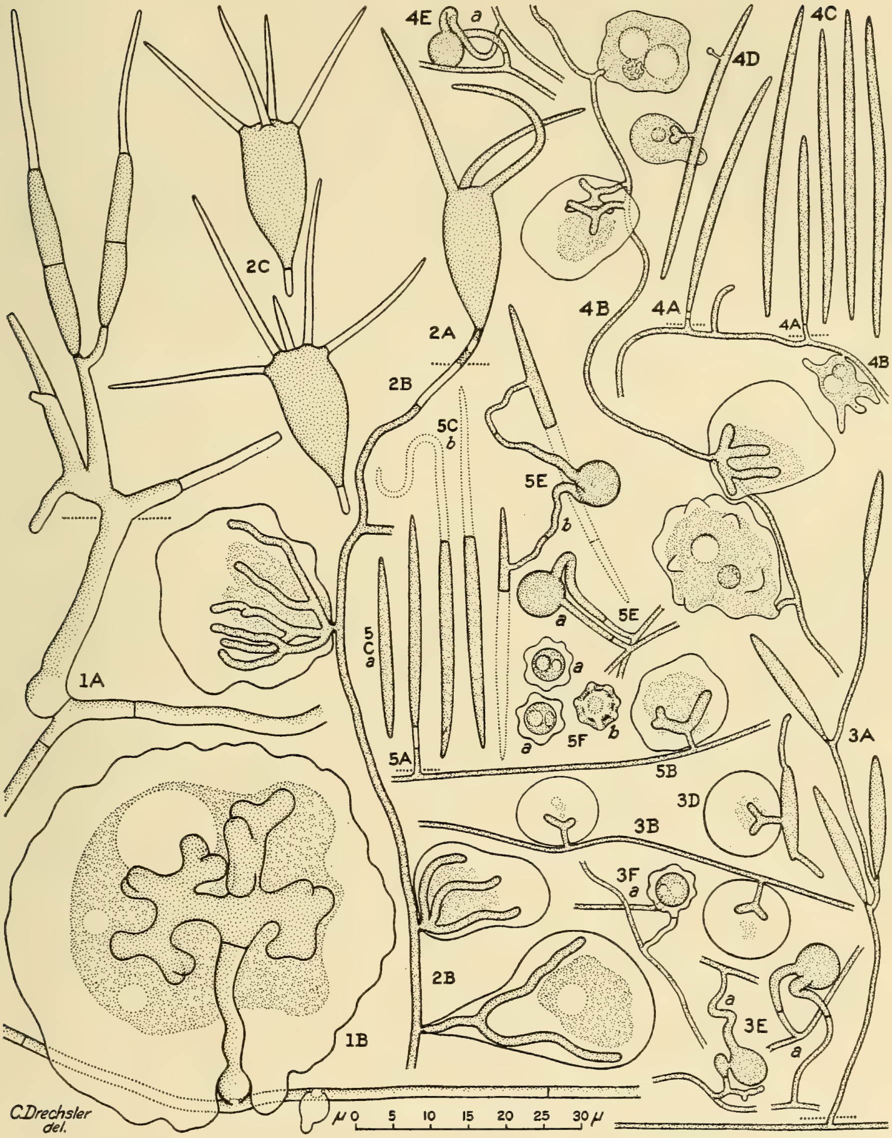
NEW MEXICO: Guadalupe Mountains, *Amer. Gr. Nat. Herb.* no. 819; Filmore Canyon, Organ Mountains, *Hitchcock* 3773.

BOTANY.—*Morphological features of some fungi capturing and killing amoebae.*[1] CHARLES DRECHSLER, Bureau of Plant Industry.

Amoebae developing in agar plate cultures started from plantings of diseased rootlets and other decaying plant materials were found to be captured and killed often in large numbers by various fungi.[2] A protozoan of large size identified provisionally as *Amoeba verrucosa* was preyed upon by a fungus distinguished by rather short, somewhat tapering, sparingly branched, noticeably but not markedly differentiated conidiophores bearing elongated 2-celled conidia, the latter individually having an empty third cell present as an apical appendage nearly equal in length to the two living cells taken together (Fig. 1, A). Capture was effected by the animal being held fast on short, rather globose, ultimately somewhat yellowish adhesive protuberances borne laterally on prostrate superficial hyphae. At the place of contact the animal's pellicle was soon perforated and a somewhat expanding hyphal outgrowth thrust toward the center of the host where through close successive dichotomous branching in three planes (Fig. 1, B) a fairly intricate complex of swollen elements was produced, which though at first continuous, later with the exhaustion of the protoplasm of the host, became closely septate. A smaller amoeboid organism was captured through adhesion to the prostrate, narrow, non-septate, superficial hyphae of a fungus bearing on short undifferentiated aerial hyphal branches or on short, undifferentiated,

[1] Received March 10, 1933.

[2] Detailed descriptions and taxonomic discussion of these forms are reserved for a more comprehensive account of predacious fungi which is in preparation.



Figs. 1–5.—Various amoeba-capturing fungi, each numeral denoting a separate species, all drawn with the aid of the camera lucida at the same magnification; ×1000. A, Conidiophore or conidiophorous hypha, the proximal beginning of the aerial part being indicated by a heavily dotted line. B, Captured amoebae adhering to prostrate filament, mostly with development of fungus within. C, Detached conidia. D, Conidium with germ tube directly invading animal host. E, Sexual apparatus showing union of oogonium and antheridium, these being borne on (*a*) mycelial branches or on (*b*) germ tubes. F, Mature oospores with enveloping oogonial walls, shown (*a*) in optical section and (*b*) in surface aspect.

aerial prolongations of prostrate hyphae (Fig. 2, A) 1-celled inversely flask-shaped spores, that are provided at maturity with a short, empty, basal stipe and 2 to 6, usually 3 to 5, divergent, gradually tapering, empty, subapical appendages, of lengths approximately equal to the length of the living cell (Fig. 2, C.) A yellow deposit of adhesive material marked each place of contact, through the center of which the fungus proliferated a narrow outgrowth that perforated the animal's pellicle to give rise within to an open bushlike ramifying system of subequal hyphal elements, the branching being of moderate extent and occurring mostly at or near the point of entry (Fig. 2, B). Amoeboid animals of smaller dimensions were captured through similar adhesion on the very delicate, superficial, non-septate, prostrate hyphae of a fungus bearing fusoid, non-septate conidia on erect, otherwise undifferentiated, aerial hyphae either singly or in some number following repeated continued growth of the filament (Fig. 3, A). Frequently here the mycelial development within the host is limited to a narrow stalk terminating dichotomously in two short but slightly expanded divergent arms (Fig. 3, B). Slightly greater but very similar mycelial development occurs within the somewhat larger amoeboid animals captured through adhesion (Fig. 4, B) on the very delicate, prostrate, superficial, non-septate hyphae of a fungus bearing on usually very short, erect, undifferentiated branches (Fig. 4, A) aerial, acicular conidia without appendages (Fig. 4, C). In a fungus morphologically closely similar to the last, but the originally acicular conidium (Fig. 5, C, *a*) of which on maturation becomes evacuated in the distal portion so as to bear an empty apical appendage often about equal in length to the living cell (Fig. 5, C, *b*), similar development of mycelium within similarly small amoeboid organisms (Fig. 5, B) is associated with further parallelism in absence of septation in the mycelium, in mode of capture and in sporulating habit (Fig. 5, A).

In addition to their decidedly caducous, colorless conidia the three fungi last referred to each produce on or in the substratum a yellow oospore, the polygonal or sigillate outer profile of which (Figs. 3, F, *a*; 5, F, *a*) is associated with sculptured ridged external thickenings of the oospore wall (Fig. 5, F, *b*). This oospore in all three species is produced through the fertilization of a terminal globose oogonium by a slightly expanded terminal antheridium borne on a branch arising from a neighboring hypha (Figs. 3, E, *a*; 4, E, *a*; 5 E, *a*). Not infrequently the germ tube from a conidium gives rise rather directly to a sex organ (Fig. 5, E, *b*), just as in other instances it very directly penetrates a host animal (Figs. 3, D; 4, D).

BOTANY.—*A new disease of dahlias.*[1] THELMA BENNETT POST,[2] Bureau of Plant Industry. (Communicated by CHARLES DRECHSLER.)

Diseased dahlia stems received from Columbia, South Carolina, on July 29, 1932, bore both the pycnidial and sclerotial[3] stages of *Macrophomina phaseoli* (Maubl.) Ashby (1).[4] The specimens consisted of thick sections of stem from near the base. Most of the stem tissue was blackened, but some green water-soaked tissue was still evident. The pycnidia occurred in great numbers in the epidermis of the blackened areas. As the stem tissue dried, the fibers separated easily and the ends were split and frayed. Most of the pith had disappeared, leaving only a thin brittle remnant in which the sclerotia were imbedded in such profusion that it had the appearance of a black crust. No pycnidia were observed in this remnant and the sclerotia were not found elsewhere.

THE PYCNIDIA IN CULTURE

Sections of the leaf petioles, the stem, and the patch of green tissue remaining on the dahlia stem were planted after surface sterilization on acid corn meal agar and after three days sclerotia became visible to the unaided eye. No pycnidia appeared in these cultures. On the other hand, mature pycnidia of *Macrophomina phaseoli* appeared in a culture secured from sections of the tissue containing sclerotia eighteen days after the planting was made. This culture was on an acid corn meal agar plate and the appearance of pycnidia was preceded by abundant development of sclerotia (Fig. 7).

Spores from the pycnidia produced in culture were observed to germinate readily on potato dextrose agar and in a 2 per cent dextrose solution in sterilized tap water (Fig. 8). On the other hand, when spores from the pycnidia found on the host were planted on various media, i.e., corn meal, potato dextrose, and string bean agar, no germination occurred, although repeated trials were made. Small (2), who tried unsuccessfully to germinate the spores of pycnidia found among sclerotia of *Rhizoctonia bataticola*, attributed the failure to the fact that the trials were made two years after the material was collected and that the spores were therefore too old. The pycnidia and

[1] Received January 3, 1933.
[2] The writer is indebted to Dr. Freeman Weiss for assistance in preparation of the paper and to Dr. L. L. Harter and Miss Vera K. Charles for criticism and suggestions.
[3] Commonly designated as *Rhizoctonia bataticola* (Taub.) Butler.
[4] Identification suggested by Vera K. Charles.

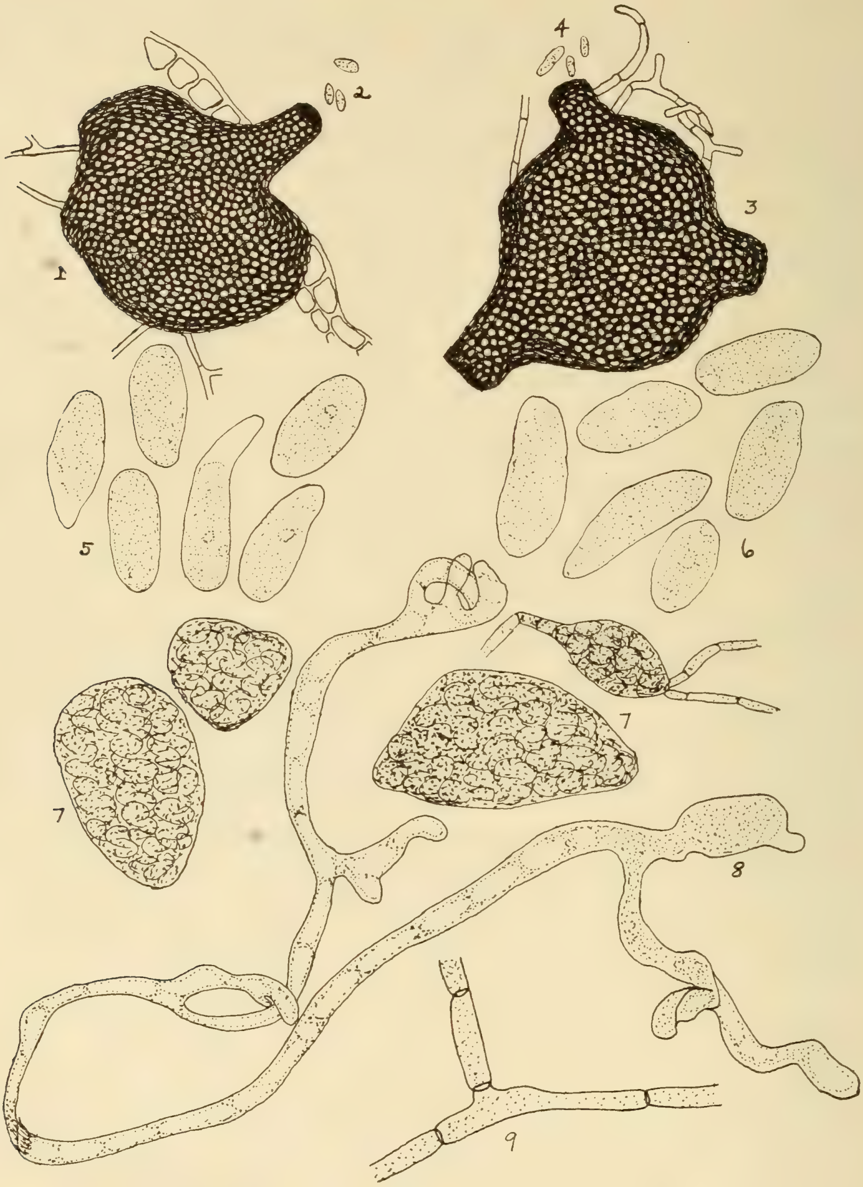


Fig. 1.—Pycnidium of *Macrophomina phaseoli* from dahlia tissue, (×200). Fig. 2.—Spores from above pycnidium, (×200). Fig. 3.—Pycnidium of same from culture (Leonian malt agar) showing development of several ostioles, (×200). Fig. 4.—Spores from above pycnidium, (×200). Fig. 5.—Spores from pycnidium on host, (×950). Fig. 6.—Spores from pycnidia of culture on dahlia stem. (×950). Fig. 7.—Sclerotia from culture on corn meal agar, (×200). Fig. 8.—Spore germinated in sterile tap water plus 2% dextrose. Drawn eighteen hours after being placed in the solution, (×950). Fig. 9.—*M. phaseoli* mycelium taken from culture on bean plug, (×950). All figures drawn with the aid of the camera lucida.

spores from the dahlia material were young and their failure to germinate in the writer's cultures could not be attributed to age.

Cultures were later made from the fibrous roots of the dahlia and the sclerotium-bearing fungus was recovered. No pycnidia developed in these cultures.

Spores from the pycnidia obtained in culture were placed in the liquid of tubes containing steamed dahlia stems. The stem was soon overgrown with mycelium, and mature pycnidia appeared five days after the inoculation (Fig. 6). Pieces of epidermis from these stems were planted on plates of various media, i.e., Leonian malt-agar, potato dextrose, corn meal, and string bean agar. On each medium pycnidia and sclerotia developed (Fig. 3). Spores were placed in the liquid of tubes containing sweet clover stems, sunflower stems, and string bean plugs. In each of these the fungus grew rapidly and produced numerous sclerotia, but no pycnidia appeared. As remarked by Haigh (3), "it is evident that a particular set of conditions . . . is necessary for their production."

The production of the pycnidia in culture is noteworthy, as they have only been recorded twice. Haigh (3) reported the occurrence of six or eight pycnidia of *Macrophomina phaseoli* in a culture of the so-called *Rhizoctonia bataticola* (Taub.) Butl. This culture was on maize meal, and was grown from a single spore of *M. phaseoli* obtained from beans affected with "ashy stem blight." The culture was so old that it was drying out at the edges. These pycnidia were larger and more elongated than those he had found in nature. Single spore cultures from these pycnidia always gave rise to pure growths of the fungus *Rhizoctonia bataticola.* There was no further report of the pycnidia in culture until in 1930, when Haigh (4) again obtained them. This time they were produced in a strain of the *Rhizoctonia bataticola* isolated from *Cajanus indicus.* Spores and sclerotia continued to produce pycnidia and sclerotia in culture, and Haigh regarded the strain as a saltant from the original culture of *R. bataticola* from *Cajanus.*

Whether the *M. phaseoli* reported in this paper arose as a saltant from the sclerotial fungus or from mycelium that may have been present among the sclerotia in the tissue from which the plates were made is not evident.

Three plates were made in the same manner from similar pieces of sclerotium-bearing tissue, but in only one did pycnidia appear. Furthermore, as pointed out earlier in this paper, pycnidia were observed only in the epidermis of the dahlia stem and not in the remnant of the pith where the sclerotia appeared. The rare occurrence of

the pycnidia in culture, despite the numerous cultures made by various workers over a period of several years, would seem to indicate saltation as the most tenable theory.

SINGLE SPORE CULTURES

Single spores grown on corn meal, beef, and potato dextrose agar gave rise to pure cultures of the sclerotium-bearing fungus and a fungus that produced both sclerotia and the pycnidial stage of *Macrophomina phaseoli*. The cultures producing pycnidia have been transferred and retransferred and have continued to produce pycnidia and sclerotia. The single spore cultures that produced the sclerotium-bearing fungus have also been transferred and retransferred, and no pycnidia have appeared in them.

DESCRIPTION OF THE FUNGUS

The pycnidia found in the epidermis of the dahlia stem in nature (Fig. 1) were 171–198μ in diameter and the spores (Fig. 2 and Fig. 5) were 18–25$\mu \times$7.2–9μ. These dimensions compare with the pycnidial dimensions of *Macrophomina phaseoli* (Maubl.) Ashby,[5] which are given (1) as mostly 100–200μ in diameter, and for the spores as 20–30$\mu \times$8–10μ. The thin-walled angular cells described by Ashby (1) are plainly visible in the young, immature pycnidium. The pycnidia became black and carbonaceous with age. The pycnidia on potato dextrose agar are 136–200μ and the spores are 18.2–28$\mu \times$7.2–10.8μ.

The sclerotia found in the pith in nature were 62μ to 117μ in diameter, while on potato dextrose agar they ranged from 40 to 80μ in diameter. Ashby (1) gives the sclerotial dimensions of *M. phaseoli* as 50–100μ in diameter in the tissues of herbaceous plants and as having the same dimensions in culture. He adds that Small found them up to 0.8 to 1 mm. in diameter in the roots of woody plants.

Haigh (4) separates the sclerotial forms of *Rhizoctonia bataticola* into three strains according to their mean sclerotial diameter. "As far as is known at present," he writes, "the pycnospores of *Macrophomina phaseoli*, from whatever source they were isolated, have always given in culture sclerotia which belong to the lowest of these groups." This, he believes, accounts for Ashby's remark that in cultures the variation of the sclerotia of *M. phaseoli* is 50 to 200μ. Haigh believes that it may be found that the two large sclerotial strains (A and B) have no connection with *M. phaseoli*. The size of the sclerotia from the dahlia tissue and of the spores from monosporous cultures, as reported

[5] The taxonomic position of the fungus is not clear and further study on this subject is intended.

in this paper, places them in strain C of Haigh's classification and further bears out his theory regarding the connection between that strain and *M. phaseoli*.

The pycnidia produced on the culture media displayed a tendency to form several ostioles, as many as four being found on one pycnidium. The pycnidia were also of greatly variable shapes and sizes. Those formed on the steamed dahlia stems appeared to be like those formed in nature, with single ostioles. They were produced abundantly and were filled with pycnospores. In no case was evidence of a stromatic origin found.

TAXONOMY OF THE FUNGUS

In 1904, D'Almeida and da Camara (5) found a *Macrophoma* on the branches of *Dahliae variabilis* Desf., in the Coimbra botanical garden in Portugal, which they named *Macrophoma henriquesiana*. They gave the diameter of the pycnidia as 140–190μ and the spore dimensions as 17–23$\mu \times$5–8μ. Although the spore measurements are slightly smaller than those given for *Macrophomina phaseoli* (20–30μ $\times$8–10μ), they are essentially the same, and the descriptions in other particulars tally. The drawings of the spores of *Macrophoma henriquesiana* are suggestive of those of *Macrophomina phaseoli* (Maubl.) Ashby. Ashby (1) has pointed out that variations in spore size on the same host may be considerable. Shaw (6) gave for them, as a maximum range on jute in India, 16–29$\mu \times$6–11μ and Sawada (7) for the same host in Formosa gave the spore dimensions as 16–23$\mu \times$7–10μ. It thus appears probable that *Macrophoma henriquesiana* d'Alm. & da Cam. is identical with *Macrophomina phaseoli* (Maubl.) Ashby and should be added to the list of synonyms.[6]

Small (2) found the sclerotia of *R. bataticola* in the roots and stems of dahlias in Ceylon, but does not report having found the *Macrophomina* stage in these plants. The sclerotia also developed on the skin of dahlia tubers that appeared to be healthy, but whose roots and stems were diseased.

A fungus disease of dahlias called "black blight" is mentioned but not identified in a list of Scottish fungus diseases published by Alcock and Foister (8) in 1931.

[6] The synonyms as given by Ashby (1) are: *Macrophoma phaseoli* Maubl. (1905), *Sclerotium bataticola* Taub. (1913), *Macrophoma corchori* Saw. (1916), *Macrophoma cajani* Syd. & Butl. (1916), *Macrophomina phillipinensis* Petr. (1923), *Rhizoctonia lamellifera* Small (1924), *Rhizoctonia bataticola* (Taub.) Butl. (1925), *Dothiorella cajani* Syd. & Butl. (1925), *Macrophoma sesami* (1922).

ETIOLOGY

The conditions of infection of the dahlia by *Macrophomina phaseoli* are not known. The tubers which produced the dahlia stems studied were new stock purchased from four separate firms. They were planted in a site that had been used as a vegetable garden for years, but there is no record of these vegetables having been diseased. At the present time there are vegetables growing in close proximity to the dahlias and these appear to be healthy. The dahlias grew and flowered in normal fashion until July, when the disease appeared. All the plants (about three dozen) were affected.

Ashby (1) asserts that the parasitism of *Macrophomina phaseoli* appears to be much influenced by the effect of environmental and nutritional conditions on the host. Haigh (4) concludes from his experiments that special conditions are required for successful inoculation with the fungus called *R. bataticola,* whose connection with *M. phaseoli* has been demonstrated.

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PALEOBOTANY.—*A new* Lygodium *from the late Tertiary of Ecuador.* Edward W. Berry, Johns Hopkins University.[1]

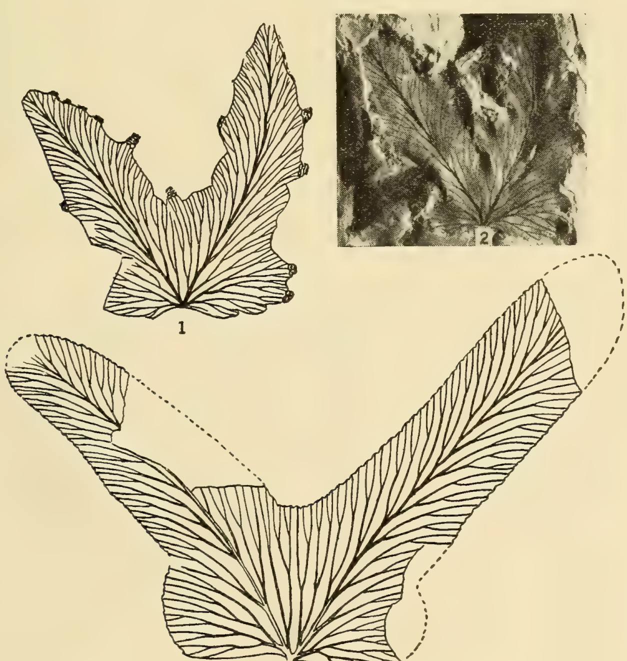
Among the large amount of material from the Loja basin in southern Ecuador which I owe to the industry of Professor Clodoveo Carrión of Loja there occurs sparingly small pinnules of the genus *Lygodium* Swartz of the fern family Schizaeaceae.

This represents a species which is obviously new and which differs considerably from any known species either existing or fossil. It is, however, based entirely on detached pinnules and this fact in conjunc-

[1] Received January 30, 1933.

tion with the further fact that the existing species are sadly in need of modern treatment renders a wholly adequate discussion of the fossil impossible. The latest account of the family with which I am familiar, that by L. Diels in 1902 in "Die Natürlichen Pflanzenfamilien," in so far as the genus *Lygodium* is concerned, is largely based on K. Prantl's discussion of the genus in 1881. Nearly all of the modern species are very variable and in looking over herbarium material one gets the impression, perhaps a superficial one, that the specific limits of many of the species are illy understood.

The present fossil form may be named *Lygodium bifidum* and may be briefly characterized as follows: Pinnules small, consisting of two principal lobes and an incipient basal lobe on either side. In the limited amount of material at my disposal the fertile pinnules are not much more than half the size of the sterile pinnules, as may be seen in Figs. 1–3. Both are slightly inequilateral in that one of the principal lobes is somewhat longer and it may also be somewhat broader than its fellow. If the figured specimens can be considered as typical, they show the following feature. Pinnules sessile. Base broad varying from nearly truncate and but slightly excavated in the sterile pinnule, to considerably excavated and almost cordate in the fertile pinnule. In the latter the length of the lobes from the point of attachment



Figs. 1–3. Pinnules of *Lygodium bifidum* Berry n.sp. from the late Tertiary of Ecuador. Fig. 1. Drawing of fertile pinnule ×2. Fig. 2. Photograph of fertile pinnule ×2. Fig. 3. Sterile pinnule ×2.

is 1.75 cm. and 2 cm.; the two main veins diverge at the base at an angle slightly less than 50°, at first recurving slightly and then incurving so that the tips are 1.75 to 2.0 cm. apart. In the former the length of the corresponding lobes is 2.75 cm. and 3.5 cm., the two main veins diverge at the base at an angle of about 55° and recurve so that their tips are 4 cm. or more apart. In both it is the right lobe that is longest, and in both the right basal lobule appears to be somewhat more developed than the left. The substance is not delicate at all but appears from the manner of preservation to be much thinner and much less coriaceous than in many of the existing species. The margin is entire or slightly crenulated. A single stout vein enters the base of the pinnule, but this immediately breaks up into two main forks and subsidiary branches which supply the basal lobules. The main branches are stout, prominent and flexuous, giving off alternately stout laterals which diverge at acute angles and fork once or twice as they recurve outward to the margins.

The fertile pinnules have a double row of thick sporangia preserved at intervals along the margins. These are incompletely preserved as partial cavities, but their nature is obvious and their appearance convincing, although I have been unable to find spores.

I have been unable to find any closely similar forms among existing species. Those with a bifid habit are extremely rare. There is some resemblance to *Lygodium cubense* H.B.K. of the larger Antilles but the latter has larger pinnules with more elongated lobes and more oblique veins, although no other living species that I have seen is as similar as some of the pinnules of this species, which is a highly variable one, however, and the resemblance is really not very close. There are perhaps 25 existing species most of which are tropical, although the eastern American species *L. palmatum* extends well into the Temperate Zone as does *L. japonicum* Swartz in Japan and *L. articulatum* in New Zealand. The genus is represented at the present time on all of the continents except Europe and is represented in equatorial America from Mexico through Central America and the Antilles to northern South America. So far as I know it is not found in Ecuador or Peru west of the eastern slopes of the Andes, but this enormous region has been but superficially explored botanically so that no one can foresee what a detailed knowledge of it would disclose.

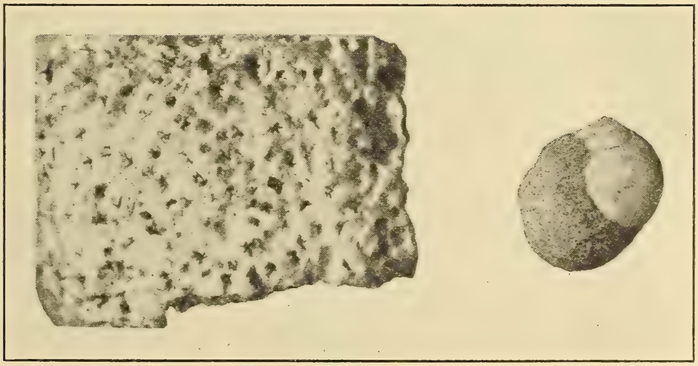
About 25 fossil species have been described but many of these are very incompletely known and are based upon very superficial differences in the form of the sterile pinnules. Supposed species are recorded from the middle Cretaceous in both America and Europe. From the beginning of the Eocene onward *Lygodium* is well represented in both America and Europe but is unknown in the United States after the Oligocene and in Europe after the Miocene. The bulk of the fossil material is of the *palmatum* type and much of it shows fruiting pinnules.

PALEONTOLOGY.—*A new species of Hydrocorallinae from the Pleistocene of New Jersey.*[1] HORACE G. RICHARDS, University of Pennsylvania. (Communicated by C. E. MCCLUNG.)

While holding a Harrison Fellowship at the University of Pennsylvania (1929–30, 1930–31), I was able to do considerable collecting in the Pleistocene deposits of New Jersey. In carrying on this work I was greatly aided by a grant from the University of Pennsylvania chapter of the Society of Sigma Xi. A complete report upon this material is forthcoming. Among this material were some very worn specimens of Hydrocorallinae (Hydrozoa) which represent a new species. Most of the material upon which the forthcoming report is based was obtained from fill from hydraulic dredging usually pumped from 30 to 55 feet below the bottom of thorofares and inlets lying back of the coastal islands of New Jersey. A large part of the material thus obtained was fossil and has been referred to the Cape May Formation which underlies these coastal islands.

Description. Polyparium encrusting on shells of gastropod mollusks; the incrustation is of one or more layers and is usually about 1 mm. or less in thickness. As far as can be observed the shell is not absorbed by the coral. On the surface at irregular intervals are distributed thick-lipped pores, the mouths of which are irregularly stellate; pseudo-septa are well marked and are usually about six in number, although variations from four to seven have been noted. The pores are not elevated above the surface of the colony; the opening between the septa is often very narrow. The average diameter of these stellate pores is 0.2 mm.

No other sets of pores can be clearly observed, although faint indications of other pores, probably round and larger than the stellate pores, can be



Milleaster interglacialis n. sp. Fig. 1.—Type, magnified 8 times. Fig. 2.—Paratype, natural size.

[1] Received December 12, 1932.

seen on a portion of the type specimen. All the material collected is very worn, and it is therefore impossible to describe the species more fully and to ascertain the relationship of the form. It resembles *Milleaster incrustans* Ulrich[2] from the Miocene of Maryland in general appearance and in the structure of the stellate pores and pseudo-septa, but differs from it in having fewer pores and in not having them elevated; it also differs from the Miocene form in the absence (or inconspicuousness) of two other sets of pores. In *M. incrustans* there is a set of pores, fewer in number than the stellate pores, which occupy the spaces between the stellate apertures; these are a little larger than the stellate pores and are irregular in shape. In the Miocene form there is also a set of very small pores scattered among the granules of the interspaces. It is possible that pores comparable to either or both of these sets were present in the New Jersey specimens, but are not visible because of the worn condition of the material.

Ulrich places another Miocene species tentatively in the genus *Milleaster*. *Milleaster* (?) *subramosus* Ulrich[3] also from Maryland consists of a series of stellate pores somewhat resembling those of *M. incrustans*. The larger of the sets of non-septate pores has not been observed, but the smaller set is well represented. As the main argument for placing this form in the genus *Milleaster*, Ulrich relies on the presence of the septate pores. This same argument might be used for placing the Pleistocene species, *Milleaster* (?) *interglacialis* tentatively in that genus also.

Type locality. Two Mile Beach, Cape May County, New Jersey; material obtained from hydraulic fill pumped from 30–55 feet below the bottom of the thorofare back of the island. (Collector, Horace G. Richards.)

Occurrence. Cape May Formation. Two Mile Beach; Holliday Beach (Stone Harbor), New Jersey.

Collection. The type and two additional specimens have been presented to the United States National Museum (type, catalogue number 371911; additional specimens, 371912, 371913).

Remarks. The fauna of the Cape May Formation seems to indicate a milder climate than that prevailing on the New Jersey coast to-day. Because of this mild fauna and for stratigraphic reasons discussed at length in the forthcoming report, the formation has been dated as belonging to the last interglacial stage.

ZOOLOGY.—*A new amphipod of the genus* Amphiporeia *from Virginia.*[1]

Clarence R. Shoemaker, U. S. National Museum. (Communicated by M. J. Rathbun.)

In the course of the survey of Chesapeake Bay by the United States Bureau of Fisheries in 1916 a number of amphipods were taken on the

[2] Maryland Geological Survey, Miocene (1904) p. 436.

[3] Loc. cit. p. 437.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received January 12, 1933.

beach between tide marks at Virginia Beach, Virginia. Upon study they appear to belong to the genus *Amphiporeia* which was first taken at Grand Manan, Bay of Fundy, by Dr. Mary J. Rathbun in 1898, and later by the Cheticamp Expedition in 1917 in the Gulf of St. Lawrence. The specimens from Virginia Beach are quite distinct from the northern species, *A. lawrenciana*,[2] and I now propose the name *Amphiporeia virginiana* for this new species.

The species appears to be very abundant as a large number of specimens were taken, but males apparently are rare, not one having been detected.

Amphiporeia virginiana n. sp.

Description of the female.—Body compressed. Eye small, oval, black. Lateral angle of head evenly rounded. Antenna 1 in the normal deflected position reaching to about the middle of the fifth joint of antenna 2, the geniculation between the first and second joints not very pronounced; first joint robust, about twice as long as high, second and third joints short and subequal in length, flagellum shorter than peduncle and composed of 6 joints, the 2-jointed accessory flagellum about equal in length to the first joint of the primary flagellum. Antenna 2, flagellum shorter than fourth and fifth peduncular joints combined and composed of 7 joints, the first joint of the flagellum being much longer than the succeeding joints and probably representing a fusion of several joints; second peduncular joint with gland-cone small, fourth joint more robust but slightly shorter than fifth. Mandible with cutting edge narrow and bearing several small teeth, accessory cutting plate well developed, 5 spines in spine row, molar prominent and strong and bearing a plumose seta on upper edge, base of molar toward spine-row bearing a small toothed seta and also a small flat tooth with upper truncate, serrate cutting edge, first joint of palp short, second joint very broad and a little longer than third with front margin very convex and densely armed with long slender spines, rear margin slightly convex and bearing a few slender spines, third joint half the width of second and having the distal half of the outer margin densely armed with long slender spines, rear margin also bearing several groups of long slender spines. Maxilla 1 much as in *A. lawrenciana*, inner plate broad and bearing 11 plumose marginal setae, outer plate very obliquely truncate and bearing 11 spine-teeth; palp, second joint broad with 7 spine-teeth and 7 slender setae on rounding apex. Maxilla 2 as in *A. lawrenciana*. Lower lip with lobes short and broad, mandibular processes short and broad, inner lobes well developed. Side-plate 1 very slightly bent forward. Gnathopod 1, sixth joint only slightly shorter than fifth and nearly as wide as long, palm oblique and curving into hind margin of joint without defining angle or defining spines. Gnathopod 2, sixth joint about two-thirds as long as fifth and about two-thirds as wide as long, palm oblique and without defining angle or defining spines, but provided throughout with a lamellar, finely serrate cutting edge. Peraeopods 1 and 2 subequal in length and proportionally alike. Side-plate 4 with shallow emargination on upper hind margin. Peraeopod 3, first joint nearly as long as second, which is nearly as wide as long, fourth joint broadly oval and

[2] Contrib. Canadian Biol. and Fisheries, 5: no. 10, p. 248. 1929.

Fig. 1. *Amphiporeia virginiana*, new species. Female, *a*, Anterior part of animal. *b*, Mandible. *c*, Molar, cutting plates and spine row of mandible much enlarged. *d*, Maxilla 1. *e*, Palp of maxilla 1 enlarged. *f*, Maxilliped. *g*, Outer plate of maxilliped enlarged. *h*, Lower lip. *i*, Distal end of gnathopod 2 enlarged.

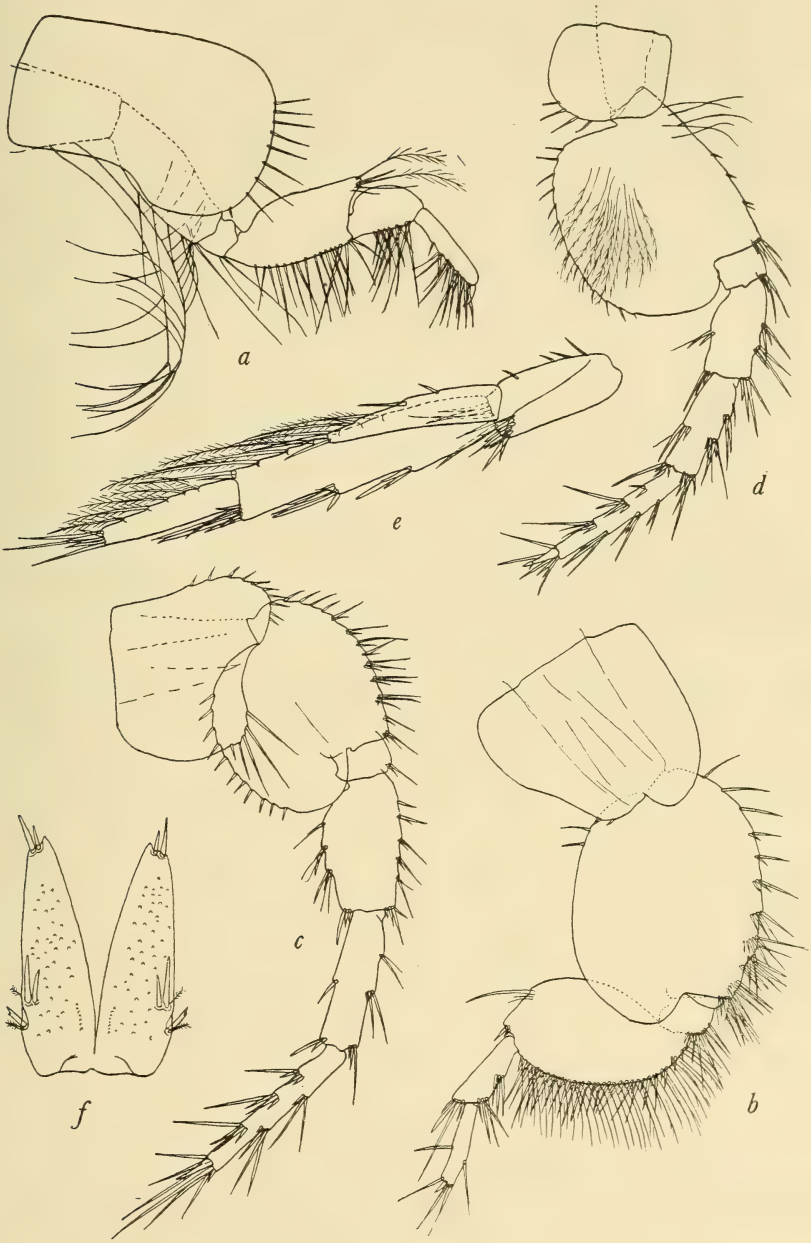


Fig. 2. *Amphiporeia virginiana*, new species. Female, *a*, Peraeopod 2. *b*, Peraeopod 3. *c*, Peraeopod 4. *d*, Peraeopod 5. *e*, Uropod 3. *f*, Telson.

armed on front margin with many long slender spines and setae, fifth and sixth joints equal in length, seventh very short. Peraeopod 4, first joint about as long as second, which is about as broad as long and very broadly expanded posteriorly, fourth and fifth joints equal in length, sixth joint longer and slenderer than fifth, seventh short. Peraeopod 5 shorter than 4, first joint half the length of the second, which is about as wide as long and greatly expanded posteriorly, fourth joint very slightly shorter than fifth, which is shorter than the slender sixth, seventh about one-third the length of the sixth. Pleon segment 3 with posterior lateral margin slightly convex and lower posterior angle evenly and rather broadly rounding. Pleon segment 2 with lower posterior corner more angular than 3. Uropod 2 reaching back as far as the end of the peduncle of uropod 3. Uropod 1 reaching back a little farther than 2. Uropod 3 long and slender, peduncle one-half the length of the first joint but equal in length to the second joint of outer ramus, outer ramus with first joint nearly twice the length of the second, first joint provided on distal half of inner margin with a row of long plumose setae and on outer margin with 2 groups of spines, second joint provided on inner margin with a row of long plumose spines and apically with a group of slender spines; inner ramus about two-thirds the length of the first joint of outer ramus, armed on inner margin with 3 spines and apically with 2 long slender spines. Telson reaching back to about the middle of the inner ramus of uropod 3, about two-thirds as wide as long, dehiscent, lobes tapering gently to the obliquely truncate apices, each of which is armed with 2 short spines, outside margins of lobes each bearing 2 groups of spines and plumose setules near their base, upper surface of telson with many minute tubercles.

Length.—Female, 7.5 mm.

Type locality.—Virginia Beach, Virginia, between tides, July 17, 1916, collected by the U. S. Bureau of Fisheries steamer *Fish Hawk;* female holotype (cat. no. 66074, U.S.N.M.).

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY

243RD MEETING

The 243rd regular meeting was held in the Assembly Hall of the Cosmos Club on October 4, 1932. Vice-president CHARLES BROOKS presided; attendance about 85.

KNOWLES A. RYERSON was elected to membership.

Brief notes and reviews: M. B. WAITE exhibited a specimen of Maryland mammoth tobacco about nine feet high which does not bloom in Maryland unless protected from frost in a greenhouse. This plant led to the studies of GARNER and ALLARD on the effect of length of day upon plants. Discussed by R. F. GRIGGS.

The summer meetings of the American Association for the Advancement of Science held in Syracuse, New York, June 20–25, were reported by R. F. GRIGGS and N. R. SMITH; the former discussing the program of the Botanical Society of America, and the latter, the program of the Society of American Bacteriologists.

H. L. SHANTZ, President of the University of Arizona and a former member of the Society was called upon by the Chairman for a few remarks.

Program: JAMES A. FARIS:—*Agriculture in Cuba.* (Illustrated by lantern slides.)

Doctor VAVILOV, Chief of the Bureau of Applied Botany, Leningrad, spoke briefly regarding the botanical work being done by the Soviet, especially in sending out expeditions to obtain new species of plants useful in agriculture.

244TH MEETING

The 244th regular meeting was held in the Assembly Hall of the Cosmos Club on November 1, 1932. President J. B. S. NORTON presided; attendance, 97.

E. E. CLAYTON was elected to membership.

F. WEISS remarked on the probability that the current list of botanical publications as published in mimeograph form by the Bureau of Plant Industry Library would have to be discontinued because of lack of funds. He offered the following resolution which was carried: That a sum not exceeding $25.00 be set aside by the Botanical Society for the purchase of mimeograph paper for the Bureau of Plant Industry Library.

N. R. SMITH proposed the following resolution: That an additional paragraph be added to Article IX of the By-laws, to wit:

Article IX

4. At the Annual Business Meeting of the Society those members in good standing who have retired from professional work during the past year shall be elected to honorary membership with all the privileges of membership but without the payment of annual dues.

Discussed by A. S. HITCHCOCK and F. THONE and carried.

Brief notes and reviews: A. S. HITCHCOCK exhibited roots of *Glycine apios,* ground nut, and discussed creeping stems and roots of various other plants. N. E. STEVENS remarked upon the inefficiency of publication. M. B. WAITE

added to the list of roots which have adventitious buds. P. V. Mook exhibited leaves of exceptional size found in an open cut-over wood. J. B. S. Norton reported that plowing *Plantago lanceolata* two inches deep either upright or up side down, was effective in killing the plant.

Program: H. B. Humphrey: *A Maryland white oak records three hundred years of botanical history.*—The speaker exhibited a polished cross-section from the trunk of an old oak felled near Cabin John. Tags bearing various dates important in botanical science were stuck into the cross-section to illustrate the size of the tree at that time.

R. F. Griggs: *The edge of the forest in Alaska and its significance.*—The great coniferous forests which stretch up the coast from Puget Sound and across the continent from Labrador to Alaska terminate in the Katmai district; the Hudsonian forest of white spruce around Naknek Lake on the mainland, and the coastal forest of Sitka spruce at Kodiak. In connection with the work of the Katmai expeditions of the National Geographic Society opportunity was afforded to study the factors fixing the position of the timber line. The trees at the edge of the forest are small and squat suggesting an adverse climate but when examined were found to be growing as rapidly as the same species a thousand miles within its borders to the southeastward, and are likewise reproducing freely. The marginal trees are small because they are young. None of the trees within a mile of the forest border at Kodiak are more than a hundred years old. There are no fallen logs nor other remains of trees older than the present generation. Many trees now standing in thick forest have large dead branches clear to the ground and evidently began life in the open. Three miles back from the forest border the trees are more than three hundred years old and have attained great size. Dead trees and fallen logs are present as in ordinary forests. Several early accounts of Kodiak describe as treeless areas now occupied by heavy forest. Instead of being held in check by climatic factors this forest is rapidly migrating into new territory. Quotations from other observers indicate that similar conditions are general all along the forest front of Alaska and in Scandinavia. The pollens preserved in peat bogs at the forest edge also show that the spruces are recent arrivals—too recent to be represented in the consolidated peat which carries only traces of spruce pollen, such as would be blown in from a long distance. The present trees are thus the only spruces that have grown in the vicinity since the beginning of the bog. The advance of the forest is a secular migration rather than part of a long-term oscillation back and forth. The forest migration thus demonstrated is taken to be a continuance of the readjustment since the last glaciation. It suggests that the vegetation of boreal and north temperate regions generally may not yet have fully recovered from the last glacial period. Means of investigating this question are outlined.

It is of the utmost importance to determine whether vegetation lines are static, held by climatic control as has generally been assumed, or whether they are like the forests of Alaska dynamic, representing merely the present positions of active plant and animal migrations. If it should turn out that we can detect and follow the present movements of species generally an entirely new field of biology will be opened up. (*Author's abstract.*)

Paul W. Bowman: *Pollen analysis of a Kodiak bog.*—Samples of peat were brought from a bog on the island of Kodiak, Alaska, during the summer of 1930 by R. F. Griggs. This bog is located several miles from the edge of the spruce forest and is surrounded by well-grown trees. The upper three

feet of this deposit were too soupy to permit the collection of cores. Examination of numerous strata from this point to the bottom at thirteen feet reveals an abundance of spores in most levels. The bulk of these, however, were contributed by several ferns, and only an occasional spore of spruce was seen among thousands of others. In the surface layer of a Quebec bog which is covered with a mixed forest of spruce, fir, and birch three-quarters of the total spores present were contributed by these trees. It may, therefore, be inferred that the Kodiak forest did not exist at this place during the early stages of the formation of this bog and that it advanced to and beyond this location during the formation of the upper three feet of peat. (*Author's abstract*).

Discussed by A. S. HITCHCOCK, C. F. SWINGLE and W. J. HUMPHREYS.

245TH MEETING

The 245th regular meeting was held in the Assembly Hall of the Cosmos Club on December 6, 1932. President J.B.S. NORTON presided; attendance, 80.

The following were elected to membership: R. C. COOK, PAUL R. MILLER, NELLIE W. NANCE, and THELMA BENNETT POST.

N. E. STEVENS made a motion that the dues of the Society be reduced at least by 16⅔ per cent. After some discussion, the motion was amended to reduce the dues to $2.00, making Article IX, Section 1 of the By-laws read, "The annual dues for members of the Society shall be $2.00."

Brief notes and reviews: DAVID GRIFFITHS reviewed the Lily Year-book of the Lily Commission of the Royal Horticultural Society. FREEMAN WEISS remarked upon a fad which may enjoy some vogue in European literature, viz.; the nature of plant immunity and resistance. J. M. SHULL exhibited normal and greatly elongated shoots of *Eleagnus pungens*. CHARLES DRECHSLER exhibited a magnolia leaf infected with the alga *Cephaleuros virescens*. Discussed by F. THONE, M. B. WAITE and W. W. DIEHL.

Program: J. B. S. NORTON: *Lady Roses and Honorable Potatoes.* (*Opinions on naming cultivated plants.*)

The meeting adjourned about 9:15 followed by the annual meeting.

32ND ANNUAL MEETING

The 32nd annual business meeting and election of officers was held following the adjournment of the 245th regular meeting.

The report of the Recording Secretary was read and approved as follows:—

During the past year there have been eight regular meetings, two special meetings and one outing. The annual dinner was held in connection with the 241st regular meeting at the University of Maryland. Average attendance at the regular meetings was 108. Thirteen new members have been elected, three absent members have been reinstated, six have resigned. Two members have died, C. D. MARSH on April 23, and HEINRICH HASSELBRING on November 9, 1932. The membership list shows a net gain of 8 or a total of 210. GEORGE C. HUSMANN, retired during the year, and was elected to honorary membership, in accordance with section 4 of Article IX of the By-laws.

The following officers were elected: *President:* CHARLES BROOKS; *Vice President:* NATHAN R. SMITH; *Recording Secretary:* CHARLOTTE ELLIOTT; *Corresponding Secretary:* FREEMAN WEISS; *Treasurer:* EDITH CASH; *Vice President of the Washington Academy of Sciences:* C. L. SHEAR.

NATHAN R. SMITH, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

Sixteenth Session of the International Geological Congress.—The third circular for the sixteenth session of the International Geological Congress, which is to meet in Washington, U. S. A., from July 22 to 29, has been issued. It contains full information about meetings and about excursions, with costs. Before the Congress there are excursions to various parts of the eastern United States, lasting from 4 to 12 days, and a trans-continental excursion eastward from San Francisco for those coming to the Congress from the west. For those arriving at New York too late to take part in these longer excursions there will be a number of short trips to nearby areas of geologic interest.

Alternate days during the sessions of the Congress will be given to excursions to areas around Washington.

After the sessions there will be two longer transcontinental excursions, each lasting 31 days, and two shorter excursions, one for the study of the glacial geology of the Central States, and the other for the study of the pre-Cambrian area, including the iron and copper deposits, of the Lake Superior region.

In order to make these excursions generally available, it has been possible, through the generous assistance of the Geological Society of America, to offer the longer excursions at a considerable reduction below actual cost.

For special discussion at the scientific sessions in Washington the following topics are announced:

Measurement of geologic time by any method.
Batholiths and related intrusives.
Zonal relations of metalliferous deposits.
Major divisions of the Paleozoic era.
Geomorphogenic processes in arid regions and their resulting forms and products.
Fossil man and contemporary faunas.
Orogenesis.
Geology of petroleum.
Copper resources of the world.

Membership in the Congress is open to any one interested.

For a copy of the third circular or other information address W. C. Mendenhall, General Secretary, U. S. Geological Survey, Washington, D. C.

Thirteenth Successive Mild Winter.—Mild winter weather, prevailing in the eastern United States during the season of 1932–33, has continued an unparalleled record for a succession of winters with temperatures above normal, the U. S. Weather Bureau states. Of the past thirteen winters, twelve have given St. Louis above-normal temperatures; New York has had ten out of the thirteen, with the past six all above normal; and Washington can now boast of the thirteenth warm winter in unbroken succession.

Light Water.—Water of low specific gravity has been manufactured in the chemical laboratories of the U. S. Bureau of Standards, by the combina-

tion of hydrogen and oxygen containing high proportions of their respective lightest isotopes ($H=1$; $O=16$). It is about thirteen parts per million lighter than normal water. Last year "heavy water," containing high proportions of hydrogen isotope 2 and oxygen isotopes 17 and 18, was made in the same laboratory. This "heavy water" has a freezing-point 0.05°C above that of ordinary water, its boiling-point is higher and its refractive index lower. It is expected that the new "light water" will depart from the physical constants of normal water in the opposite way, but to a smaller degree, corresponding to its lesser difference in specific gravity.

New Solar Radiation Station in Sinai.—Messrs. HARLAN H. ZODTNER and FREDERICK A. GREELEY of the Astrophysical Observatory of the Smithsonian Institution sailed on March 4 for Suez, taking with them about six tons of equipment for installing a solar radiation station on Mount Saint Katherine, Sinai, Egypt. The authorities of the Saint Katherine Monastery on Mount Sinai have agreed to construct the observatory and trails. The expedition, financed by JOHN A. ROEBLING, is expected to continue three years, cooperating with the Institution's two solar radiation observatories at Montezuma, Chile, and Table Mountain, California. Mount Saint Katherine, whose summit is about 8,500 feet above sea level, was selected after about twenty months of exploration by Mr. and Mrs. A. F. MOORE.

Marine Shells in Virginia Triassic.—Imprints of fossil seashells have been found in the Triassic Belt of Virginia, near Bull Run, by Dr. ARTHUR BARWICK, acting head of the department of Geology at the Catholic University of America. So far as he has been able to discover, marine shells have not previously been reported from this formation. The Virginia Geological Survey has collected many plants from the Triassic and is cognizant of the footprints of several types of dinosaurs. Little has been found to date, however, that would prevent these deposits from being classified as continental facies as the corresponding deposits of New Jersey and New England are generally thought to be. If these shell remains definitely prove to be members of the Ostreidae, as the cursory studies to date would indicate them to be, it would prove that part of the Triassic deposits of Virginia, at least, were of marine origin.

Activities at the Brookings Institution.—In the Institute of Economics the following research projects have recently been brought to completion:

Advertising Allowances: A Phase of the Price-Making Process LEVERETT S. LYON.

Ten Years of Federal Intermediate Credits, FRIEDA BAIRD and CLAUD L. BENNER.

The American Federation of Labor: History and Outlook, LEWIS L. LORWIN.

Silver: An Analysis of Factors Affecting Its Price, Y. S. LEONG.

Trend Analysis of Statistics: Theory and Technique, MAX SASULY.

When the National Transportation Committee was set up last fall under the chairmanship of the late ex-President Calvin Coolidge, the committee turned to the Brookings Institution to prepare the report on the transportation situation on which they would base their findings. This investigation was organized by Dr. H. G. MOULTON, with a staff consisting of certain members chosen from the Institute for Government Research and from the Institute of Economics, together with several specialists from outside. The investigation has been completed and the committee has issued its analysis

and recommendations. The full report is being published under the title "The American Transportation Problem" in a volume of about 900 pages by the Brookings Institution.

News Briefs

One of the last official acts of former President Hoover was the creation in the Boulder Dam area of a wild life preserve several thousand acres in extent, designed primarily to be a bird refuge.

Work has been started on the reconstruction of the two transit circle houses at the U. S. Naval Observatory.

Dr. Barnum Brown, Curator of Fossil Reptiles of the American Museum of Natural History, discussed with U. S. National Park Service officials the possibility of a development at Dinosaur National Monument in Utah that would provide visitors with a view of a dinosaur skeleton left in place on a rocky wall.

The Institute for Government Research of the Brookings Institution, at the request of Governor Clyde Herring of Iowa, is engaged upon a financial and administrative survey of that state.

Mr. J. B. Morgan, 2nd, of radio station W3QP, at Philadelphia, through whom radio communication between the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and its magnetic observatory at Watheroo, Western Australia, is maintained, reports that transpacific radio conditions were nearly perfect during the second week in February.

Work has been begun at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington on an extension to the Experiment Building for the purpose of housing the two-meter Van de Graaff generator which was built and subjected to preliminary tests in Washington during May, 1932. This will make possible experiments with protons and other ions at voltages of one and one-half million volts and more. Atomic-disintegration experiments have heretofore been carried out with a smaller generator in the present building at potentials up to 700,000 volts.

A huge quartz geode, obtained by Mr. E. P. Henderson at Keokuk, Iowa, last summer has been placed on exhibition at the U. S. National Museum. It is one of the largest specimens of its kind ever found.

Word has been received from Dr. Walter Hough, Head Curator of Anthropology, that he has found additional remnants of prehistoric canals throughout the Salt River Valley, Ariz.

The expedition which the Carnegie Institution of Washington has organized to explore southern Campeche and northern Guatemala in search of new archaeological sites representing ancient Maya culture left Campeche for the interior on March 4. It will be out about three months and, before returning, will probably go as far south as Uaxactun, Guatemala, where the Institution is conducting important excavation. The expedition is headed by Karl Ruppert of the Institution's archaeological staff.

Among recent births at the National Zoological Park is a baby eland whose mother died when it was born. After refusing food for a time the little animal consented to take milk from a bottle and is being brought up "by hand."

By exchange with the American Museum of Natural History, New York, the Division of Vertebrate Paleontology, U. S. National Museum has recently acquired two specimens of exceptional interest, the first a nearly complete skeleton of *Moropus* from the Lower Miocene of Nebraska, a clawed ungulate mammal as large as the modern camel. The second is an articulated skeleton of the large carnivorous dinosaur known as *Gorgosaurus libratus* and found in the famous Red Deer River region of Alberta, Canada. Both specimens pertain to genera not previously represented in the paleontological exhibits.

At the National Institute of Health, a vaccine has been made from rat fleas infected with typhus fever, which protects guinea pigs from the disease and promises to develop into a protective vaccine for human beings also.

Maleic acid has been found to be a good preventive of rancidity in edible oils and fats, by Dr. G. R. Greenbank of the U. S. Department of Agriculture. One part in ten thousand is effective. Dr. Greenbank has applied for a public patent on his discovery.

Personal Items

Dr. Georg Masing, Metallurgical Director of Siemens-Halske and President of the Deutsche Gesellschaft für Metallkunde, addressed the scientific staff of the Bureau of Standards on February 17. He also addressed the Washington Society of Engineers and the Washington Chapter of American Society for Steel Treating. Dr. Masing was in this country for the purpose of delivering the Annual Lecture to the Institute of Metals, at the annual meeting of the American Institute of Mining and Metallurgical Engineers in New York, during the week of February 20.

Mr. H. H. Bennett of the Bureau of Chemistry and Soils, and Mr. Lewis A. Jones of the Bureau of Agricultural Engineering, U. S. Department of Agriculture, spoke before the National Drainage, Conservation and Flood Control Congress held at Columbus, Ohio, in mid-February.

Mr. Warren E. Emley, Chief of the Organic and Fibrous Materials Division of the U. S. Bureau of Standards, gave a talk before the Central Pennsylvania Section of the American Chemical Society on March 16, at State College, Pennsylvania.

Dr. Waldo Schmitt, with the Hancock Galapogos Expedition, returned to Panama March 6, after a month's collecting in the Galapogos Islands. The expedition then made collections along the coast of Central America and returned to San Diego the latter part of March.

ANNOUNCEMENTS OF MEETINGS

The ACADEMY will meet at the Cosmos Club on April 20. Dr. HENRY E. SIGERIST, Director of the Institute of the History of Medicine, Johns Hopkins University, will address the Academy.

The Philosophical Society announces the following programs:

April 22. R. W. GORANSON and L. H. ADAMS.—*The precise measurement of birefringence.*

C. S. PIGGOTT.—*Radio-active isotopes and the problem of geological time.*

May 6. A program on "Physical Metallurgical Research."

The National Academy of Sciences will meet April 24, 25, and 26.

The American Physical Society will hold its Washington meeting on April 27, 28, and 29. On the afternoon of April 27, there will be a symposium on hydrodynamics at the Bureau of Standards. One of the speakers will be Dr. TH. VON KÁRMÀN, director of the Guggenheim Aeronautical Laboratory, California Institute of Technology, Calif. The symposium will be followed by an inspection of the National Hydraulic Laboratory.

The Acoustical Society of America will meet in Washington on May 1 and 2.

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JOURNAL

OF THE

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JOURNAL

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WASHINGTON ACADEMY OF SCIENCES

VOL. 23 MAY 15, 1933 No. 5

ENGINEERING.—*From material to structure.*[1] L. B. TUCKERMAN, Bureau of Standards.

"The name of the song is called 'Haddock's Eyes'."

"Oh, that's the name of the song, is it?", Alice said, trying to feel interested.

"No, you don't understand," the Knight said, looking a little vexed, "that's what the name is *called*. The name really is 'The Aged, Aged Man'."

"Then I ought to have said 'That's what the *song* is called'?" Alice corrected herself.

"No, you oughtn't: that's quite another thing. The *song* is called 'Ways and Means:' but that's only what it is called, you know!"

"Well, what *is* the song, then?" said Alice, who was by this time completely bewildered.

"I was coming to that," the Knight said, "The song really *is* 'A-sitting on a gate'."

The title of my talk is called "From Material to Structure." I hope the talk itself is somewhat more closely related to what the title is called than it was in the case of the Knight's song. However, words are stubborn and do not easily adapt themselves to accurate expression of our thoughts. Only under the hand of a poetic genius do they become plastic and shape to the thought of the writer. When we who are not poets are allowed to be loquacious and can hedge each word about by a multitude of qualifying adjectives and phrases we may force them to give a reasonable picture of what we wish to say.

In a title it is possible to be loquacious. You have all seen many loquacious titles, but they are not attractive. The title "From Material to Structure" was chosen for its brevity and does not give an accurate picture of the subject of this paper. It is, in fact, so general that volumes could be written, and have been written, on many topics included in its scope.

[1] Received February 15, 1933. Address of the retiring president, delivered before the Philosophical Society of Washington, January 14, 1933.

For that reason I shall spend some time supplying in my introduction some of the many qualifying adjectives and phrases which were not included in the title. As a basis for this I referred to a dictionary. Here, as usual, there was a wealth of definitions of different and only remotely related uses of the words "material" and "structure." Among these I sought out the ones which might fit into the title:

> "Material—The substance or substances or the parts, goods, stock, or the like, of which anything is composed or may be made."
>
> "Structure—Something constructed or built."

These seemed to fit the case but still were not quite definite enough to start on. Looking further I found:

> "Construct—To put together the constituent parts of (something) in their proper place and order."

To stay within some bounds let us first limit "structures" to "mechanical" structures—structures (to paraphrase a definition) "which by their design may serve to transmit or modify force or motion so as to produce some given effect or do some desired kind of work." This is somewhat more comprehensive than the usual engineering use of the word structure and we have ample material to discuss. Monkey wrenches and mill stones, automobile engines and airships, bells and bridges, all serve to transmit or modify force or motion so as to produce some given effect or do some desired kind of work. It is from this purely mechanical aspect that we shall consider them.

"From Material to Structure" would with this limitation include all the intricate steps involved in putting together ". . . in their proper place and order," "the substance or substances . . . of which anything may be made" to form a finished mechanical structure. We can, of course, consider only an infinitesimal aspect of these, but a short time devoted to a few generalities may serve to show the relation of this aspect to their bewildering complexity.

To put the materials of a mechanical structure in their proper place and order demands a knowledge of arrangements of materials capable of producing the desired effect or doing the desired kind of work. The structure must be designed before it can be constructed. This means not simply arranging some material in a suitable way but arranging suitable materials in suitable ways. There may be widely different ways of serving the same purpose.

A bridge serves the purpose of transmitting the loads of the traffic over it to its foundations and abutments. The proper place and order for the materials of a bridge of stone which shall serve this purpose

L. B. Tuckerman
President, Philosophical Society of Washington
1932

satisfactorily are not the proper place and order for the materials of a bridge of steel. The design involves, then, the relationships between properties of the material, the geometrical configuration of the structure and the purpose it is to serve.

It involves also the methods of shaping the individual pieces so that they will fit in their proper places. A certain material shaped in a certain way may be admirably adapted to a purpose, but the design is useless if no methods are available to give the material the desired shape, and another shape or even another material in another shape must be used. Long before the advent of the steel automobile body, it was known that properly shaped steel would serve the purpose better than wood. All that was lacking was the means to give it the proper shape. With the development of autogeneous welding processes and of the art of sheet metal stamping, the modern "one piece" automobile body came into being. All of you know what a change it has made in the appearance of the automobile. With the advent of new methods of shaping materials, structures designed to serve the same purpose may change wholly out of semblance to their original shape.

Into the design enters also the problem of economical construction. Costly materials will be discarded in favor of cheaper materials, costly methods of fabrication in favor of cheaper methods of fabrication, and the shape of the finished structure may be altered radically under the influence of these considerations, and not only cheaper but in most cases much more serviceable structures will result.

Although we are limiting our discussion to mechanical structures, the purposes they serve are not always purely mechanical. A house, for example, is a mechanical structure in that it serves the purpose of keeping the rain and snow from our heads, of excluding undesired currents of air, of furnishing a smooth and solid support for our feet. Its proper design and construction is, therefore, a mechanical problem.

A house which merely served the mechanical purposes of a house would hardly be considered satisfactory. We wish windows to let in the light. These must be both mechanically and optically satisfactory. We use the walls to keep out heat in summer and keep it in in winter. The walls should be not only adequate mechanically but afford adequate thermal resistance. Wood and stone and brick are poor conductors of heat, and walls of these materials which are mechanically adequate serve fairly well as heat insulators. Metal is a relatively good conductor of heat. Metal walls of the house of the future will divide

their mechanical and thermal functions between two materials, and their design will involve the satisfactory integration of structural metal with heat insulating materials of little or no mechanical value.

With all the conceivable physical purposes of a house adequately served, we still do not have a house. Intangible emotional factors, which may be loosely designated by the captions—art and style—frequently outweigh other considerations. A house does not serve its purpose unless in some measure it satisfies emotional needs. Although, in varying degree, these intangible factors influence practically every step from material to structure, to discuss them further would lead too far afield.

Thinking from material to structure we think first of available materials and their properties, then fabricated parts, then assemblages of fabricated parts, and finally of a finished structure or machine in service. Each material or group of materials furnishes the basis for a great variety of structures whose structural and dynamic possibilities are conditioned in large measure by the properties of the materials out of which they are made. From one aspect the problem of design is the problem of developing the structural properties of the materials. The line of thought from material to structure is, however, in itself, sterile. Design is intricately bound up with construction, and construction with design, but dominating them both is the purpose "to produce some given effect or do some desired kind of work."

To make our thought fruitful we must think also from the standpoint of the user of the structure. A structure is designed to serve a certain purpose. It serves that purpose in a more or less satisfactory way. From this standpoint the problem of design is to improve the quality of that service, either by improvement of the existing structure or by the substitution of a new and improved one. The designer analyzes the way in which the structure is satisfactory and the particulars in which it is unsatisfactory and reasons back through assemblages and fabricated parts, questioning their design, to the materials of which they are constructed, questioning their suitability for the purpose. He may even go further, inquiring into the possibility of securing or producing new materials with more desirable properties. Here, however, we leave the field of mechanics and enter into the field of metallurgy and chemistry.

The distinction I have just made between the two lines of thought—from material to structure and from structure to material—is, of course, largely artificial. No such sharp and clear distinction exists. Nevertheless, the distinction is real. They are two definitely different

habits of thought of two different types of engineers engaged in construction in its broadest sense. Although, in actual work, both will continually think forwards from material to structure in service and backwards from structure in service to material, the materials engineer and the designer who works with him will the more generally picture to themselves the structural possibilities of the materials at hand, and the operating engineer and the designer who works with him will the more generally picture to themselves the needs of the service and from them the designs and materials needed for a structure to serve that particular purpose.

Of these two orders of thought, the one from structure to material, is the more direct response to human desires and consequently much the older. That of the materials engineer, from material to structure, is a later development and more artificial.

"Suitable materials" arranged in "suitable ways": that is our desire. How shall we know that it is realized? The most direct answer is to build the structure and try it out, and, in fact, that it is the final answer. This is a service test in the strict sense of the words. If a service test were the only answer, structural progress would be slow and costly. A San Francisquito dam, a Quebec bridge, a poorly welded caisson in New York, a Knickerbocker Theater, a broken automobile axle: these all represent service tests that prove by the resultant loss of life and property that in these structures there were not suitable materials suitably arranged.

> "And answered Nature, merciful and stern;
> 'I teach by killing, let the others learn'."[2]

Much is gained if we can know beforehand that certain materials arranged in certain ways either will or will not make satisfactory structures. For this purpose we have materials and structural testing: materials testing to search out and measure the structurally significant properties of the material, to determine how they persist or are modified by the processes of fabrication and construction, and finally to prescribe the tests to which materials entering into given structures shall be subjected; and structural testing to determine the relations of the strength and other structurally significant properties of given geometrical configurations of materials to the properties of the material itself.

The final qualifying adjectives and phrases may now be added to make the title read:

[2] Charlotte Perkins Stetson. *In this our world.*

"Mechanical Testing of Materials and Structures in the Passage from Material to Structure."

Historically, service tests preceded materials tests or even structural tests by many years. Our pre-paleolithic ancestor found that a stick of wood in the hand formed a useful implement in securing his food or in settling various disputes with other men. At first it was probably any likely looking stick of wood picked up on the spur of the moment, but soon he learned that all sticks of wood were not equally serviceable, and a stick which had successfully withstood a service test on the skull of an enemy was preserved for the next encounter. At some time in his progress toward civilization he learned that it was not necessary to await an actual encounter to try out a stick, and structural tests were made on the nearest stump or rock.

With the shaping of the stick into a club came a new problem, the determination in advance of the laborious process of manufacture, that the materials chosen for fabrication would produce a club which would satisfactorily stand the service test. In some such way materials testing began.

As the gap between raw material and finished product grew greater, the importance of materials tests increased because of the greatly increased labor which would be wasted by fabricating unsuitable materials and the greatly increased danger from unsatisfactory structures. At first the materials tests differed but slightly in character from the service tests on the finished product, but in course of time many of them changed their character so completely that their connection with the ultimate service tests was remote and obscure.

In this development, materials and structural testing remained, through many centuries, an art intimately associated with, and a part of, the art of manufacture. Each particular manufacturing trade developed a technic of materials and structural tests necessary to its success.

This technic was largely a "rule of thumb" technic, based upon qualitative differences in behavior, often impossible to express in words, and its correct appreciation and interpretation demanded an intimate familiarity with the material, gained through years of experience in fabricating and using it. It is hard for us today, with our more scientific way of thinking, to realize the extent to which these "rule of thumb" tests were developed. Although they were often mixed with what seems to us gross superstition, such as ascribing unexplained failures to the action of malevolent demons, nevertheless they were sufficient to guide highly technical processes to successful

results. We need only recall the skill of the master armorer who rejected a piece of steel for no better reason than that "it did not feel right under the hammer." By the use of criteria, many seemingly as vague as this, were produced the blades of Toledo and Damascus.

The great industrial progress of the nineteenth and twentieth centuries with its increased specialization and multiplication of steps of partial fabrication, has been gradually destroying the intimate personal contact of the worker with the materials which he fabricates. Raw material on its way to the finished structure may now pass through dozens of hands, each contributing its share in shaping the material to its final form for service. This enormous widening of the gap between raw material and finished structure has been making it more and more nearly impossible for any man to gain the familiarity with the material which would enable him to interpret successfully the vague criteria which were the original bases of materials testing. A new development of materials testing became necessary to meet the new situation.

The bases for this new development were laid in the same scientific progress which had given rise to the changed industrial conditions. Mathematicians and physicists had delved deeply into the laws which governed the strength and deformation of bodies under load. These laws gradually took on definite form and became more and more adequate representations of the phenomena, until finally in the mathematical theory of elasticity, supplementing analytical mechanics, engineers found a safe foundation for a theory of the mechanics of materials and their assemblages into structures of many diverse shapes.

Herein lay the possibility of the new development of materials and structural testing as an independent art that is rapidly changing into a science.

It became possible for the engineer to state that a material having certain definite measurable properties, objectively expressed in figures, built into a structure of a certain design, would be satisfactory under some given conditions of service. It was then possible for anyone skilled in materials testing, although he might not know the principles on which the structure was designed nor even the use for which it was planned, to state as a result of standard tests that material submitted did or did not have the required properties. Materials testing had become objective.

In spite of the progress in the theory of elasticity, great gaps are still left. For definite knowledge we are still almost wholly confined

to the region of "perfect elasticity," and only in the last thirty years has a beginning been made in the understanding of the behavior of bodies in the region beyond the nebulous limit which separates "elastic" from "inelastic" behavior. So incomplete is our knowledge of this structurally important region that we are still not sure just what are the conditions under which a material breaks. We know, of course, with considerable accuracy, the static tensile, compressive, and shear stresses which, acting alone, will cause the yielding or rupture of many materials, but in regions of complex stress distribution, we have not yet learned how the various stresses are to be combined into a single criterion of strength or if indeed any single criterion may be found. There have been many careful investigations of the action of combined stresses, but unfortunately all of them are open to various interpretations and even in particular cases leave us still uncertain, whether maximum stress, maximum strain, maximum shearing strain, or sometimes one and sometimes the other, or perhaps some complex function of some or all of them, are valid measures of the strength of the material.

Still less are we certain of valid criteria for the case of fluctuating or alternating stresses. Failures under varying load—both impact and fatigue failures and especially the latter—are still imperfectly understood. The advent of modern high-speed machinery has brought these failures into prominence, but the experimental work on them, the necessary basis for a valid theory, although started over fifty years ago, has really only just begun.

Some few things have been learned about fatigue failures and the lesson has in many cases been costly. We know, for instance, that in parts subjected to high alternating stresses sharp reentrant angles, rough or scratched surfaces, especially at fillets; and thin outstanding fins, should be avoided like poison. Unfortunately, there are still designers and constructors who have not fully learned this lesson.

We know, also, that vibration does not cause metals to crystallize, that the characteristic crystalline fracture found in fatigue failure merely means that the crystals of which all metals are formed have not been greatly distorted as they are in static tests and that the failure has taken place along planes of weakness either in the crystals or at their boundaries.

Although this has been known for many years, men who ought to know better still talk about failures of metals caused by crystallization.

Many other gaps in our knowledge of the mechanical properties of

materials and their significance could be enumerated if time permitted, but these two are sufficient to indicate how far we are from a complete understanding of the problems involved.

The statement of these limitations may make it seem as if we were still not far from the "rule of thumb" stage of the art. This is both true and untrue. In many materials tests we know definitely what properties of the material we are seeking to determine and in a general way the relations they bear to the use of the material. Such, for instance, are the tests for tensile and compressive strength, and moduli of elasticity. These properties bear direct, and in their broad outlines at least, definitely known relations to the strength and stiffness of any structure built of the material. They form, then, reliable and indispensable bases for judging the quality of the material, and we feel sure that they will endure in practically the form in which they are at present standardized as an essential part of the technic of materials testing.

Other tests are still largely on the "rule of thumb" basis, and sometimes it seems to me that there still clings to them somewhat of superstition. We make the tests partly because there are, or seem to be, correlations between the results of these tests and the quality of the material in service, but partly, also, because they are reputed to distinguish between some good material and some bad material, and we, in our ignorance, hesitate to give them up, in a justified fear lest we may be abandoning useful tests. In these tests we often have no clear idea as to what qualities of the material we are trying to determine, nor whether, if determined, they would bear any definite relation to the serviceability of the material.

There is a common characteristic of these tests by which they may be separated from the soundly established tests. They have not been even approximately standardized and new and variant methods of making them are continually proposed. In this class the cold-bend tests which are supposed to determine the "ductility" or "toughness" of a material furnish perhaps the most striking example. Their name is legion. Some of them, with some materials, for some uses, certainly are of value, but in many cases this value is, to say the least, doubtful.

We must not, however, condemn and abandon as useless time-honored tests, merely because we have not been able to remove them from the "rule of thumb" class and give them a sound theoretical basis. We need only remember the many "hardness" tests. "Hardness," as commonly thought of, represents a hazily conceived conglomeration or aggregate of fairly indefinite properties of a material,

more or less related to each other. They are usually, but not always, mechanical properties. They include such varied things as resistance to abrasion, resistance to scratching, resistance to cutting, ability to cut other materials, resistance to plastic deformation, high modulus of elasticity, high yield stress, high strength, absence of elastic damping, brittleness, lack of ductility and malleability, high melting temperature, magnetic retentivity, etc. This confusion under the one designation "hardness" results from the fact that there is a rough parallelism in these properties in a large number of materials. The fact that "hardness," thus conceived, is a conglomeration of different, more or less unrelated properties makes it impossible to correlate any one definite, measurable property with all the current implications of hardness.

This does not mean that under the hazy conglomeration of properties which are included in the common understanding of hardness, there are not included very important properties of the material.

Nobody doubts that the "hardness" of the diamond is one of its most important physical properties, nor that it is necessary to control accurately the "hardness" of metal-cutting tools or of balance knife edges, nor that the difference between "hard" and "soft" glass is of great technical importance, nor that there is a great difference between "hard" and "soft" woods or between "hard" candy and chocolate creams, a difference which is of considerable commercial importance.

It does, however, mean that the properties implied by the term "hardness" in these different cases are so heterogeneous that they cannot represent definite, accurately comparable properties of the materials in the sense that, for example, density, moduli of elasticity, specific heat, etc. represent definite and accurately comparable properties of the materials.

With all this haziness, the "file test" of hardness still retains its usefulness in the hands of a skilled mechanic.

Even more, a few indentation tests—so-called "hardness" tests—have been progressively standardized until finally they serve as powerful tools in ensuring uniformity in the quality of millions of pieces of metal. How general the practice is, I do not know, but every axle of a well-known make of automobile bears on it the characteristic dimple—the record of a Brinell indentation test—made to ensure that it was properly tempered. Nevertheless, we know so little about the test that we are not even able to give a reliable method applicable to all materials, for comparing 500-kg Brinell hardness with 3000-kg Brinell hardness.

Materials testing is still in its infancy and only by keeping in mind the purely empirical nature of many tests, continually searching for firmer theoretical knowledge and continually comparing the results of materials tests with the results of structural and service tests, can tests be either safely discarded or placed upon the sure foundation of theory. Fortunately for our hopes for the future, the last few decades have seen the beginnings of a promising attack on the theory of plastic deformation, the phenomenon which underlies so many of the ill-defined materials tests.

In a materials test the ideal striven for is to subject a portion of the material to definitely determinable stresses and observe its behavior under these stresses. If we had some means of applying forces at will to each element of volume in the interior of the specimen this ideal could be realized. There is, however, no way in which this can be done. Practically, we can only apply forces to the surface of the specimen and the resultant distribution of stress through the specimen is beyond our direct control, since it depends not only on the surface forces which we can control but also on the shape of the specimen and nature of the material under test. Similarly, our measurements of the deformation of the specimen are practically limited to surface deformations, and from these we infer, so far as possible, the distribution of strain inside. We can, however, in simple cases so shape the specimen and so apply the load that in limited portions of the material an approximation to the desired distribution of stresses is obtained. When this is well done the strain distribution in the interior may be reasonably well inferred from the surface deformations. The ideal, however, is never reached and it is only by painstaking design of the shape of specimen and arrangement of loading devices that a reasonably satisfactory test is ensured.

Much study has been given to the design of test specimens, of testing machines and their attachments, and of strain measuring devices, and a bewildering variety of apparatus has been developed, adapted to many different kinds of materials and sizes and shapes of specimen.

The improvement of materials testing technic in the last few years has been marked, but enough more remains to be done to tax the ingenuity of future generations of testing engineers.

THE PROBLEM OF NEW MATERIALS

New materials furnish one of the most interesting problems not only for the materials testing, but also for the designing engineer. If we knew definitely the meaning of all our materials tests in relation to

the material in service, materials tests alone would furnish a solution. As we do not, the best we can do is to subject the material to our customary tests, determine to the best of our ability the uses to which it is adapted, turn it over to the designing engineer, and then await the verdict of time.

This can be best illustrated by briefly considering a type of structural material which has been developed within the past twenty years and is now coming into fairly wide use. I refer to the light aluminum base alloys of which duralumin is perhaps the most familiar.

Duralumin, an alloy containing about 95 per cent aluminum and the remainder largely copper, magnesium, manganese, and silicon, has a tensile strength approximating that of ordinary structural steel, but a density approximately one-third as much. The modulus of elasticity approximates ten million pounds per square inch (one-third that of steel).

The obvious advantage of these alloys lies in their low density and high strength-weight ratios. However, equally high, and even higher strength-weight ratios are obtained from steels. We have alloy steels in billet form with tensile strengths up to 200,000 pounds per square inch and ordinary carbon steels in wire form show strengths higher than 250,000 pounds per square inch.

In tension members the same combination of strength and lightness can therefore be obtained with the cheaper well-tried materials, so that here the light alloys offer practically no advantage. In the airship Akron, for instance, the purely tension members are practically all high-strength steel wires.

The strength of a beam or column, or any structural member, in which compressive stresses play a significant part, depends not only on the strength of the material and the area of the cross-section, but also on the linear dimensions of the cross-section and the modulus of elasticity of the material. Within limits, the further the material can be removed from the centre of the cross-section the stronger the member. This accounts for the familiar **H** and box sections of columns, and the tubular construction of bicycle frames and the fuselages of many airplanes. The limits are set by the fact that as the material is further removed from the centre of the cross-section, it necessarily is made thinner. If too thin, it crumples under compression somewhat like a sheet of paper. This crumpling depends practically upon the thickness and the modulus of elasticity, and only in small measure on the strength of the material.

In duralumin the strength-weight ratio is equal to the best of the alloy steels (except in wire form) and its modulus-weight ratio is practically the same, so that roughly speaking for the same outside linear dimensions of cross-section equal weights of material would make equally strong beams or columns. The flanges, webs, and walls of the duralumin structures would, however, be approximately three times as thick as the steel, so that the outside linear dimensions of the cross-section could be increased, with diminishing thickness of wall, without danger of crumpling. Consequently, either lighter or stronger structures can be made of duralumin. Obviously this is one of the most advantageous fields of application of these light-weight alloys. The correctness of this conclusion is attested by their successful use in airship girders and airplane beams.

With the determination of this advantageous field of application the problem of their economic use is still not solved. In spite of notable progress during the last forty years, the theory of compression members remains in an unsatisfactory state, and we are not yet able to reason with absolute certainty from the strength of one column or girder to another of similar design but of radically different dimensions. The uncertainty becomes greater when we change to materials with markedly different relations between stress and strain.

The application of these alloys has, therefore, been a slow process of successive improvement in design, continually checked not only by materials tests but even more by structural tests, until today for certain uses certain types of design seem to be approaching standardization. When we consider that the duralumin girders of the Shenandoah, strong and light as they were, developed only about 60 per cent of the strength theoretically available in the material, and the girders of the Akron of markedly better design only make use of about 80 per cent, we can see that there are still opportunities for the designing engineer. Will it be found economical, for instance, in spite of its high cost, to use duralumin in the construction of long span bridges? It is an interesting speculation which has been seriously discussed.

So far, I have mentioned only the results of the better understood materials tests in judging this relatively new material. What of the others? One example will have to suffice. For the usual high-grade structural duralumin an extension of 18 per cent in two inches is specified. Why? For some of the new modifications extensions as low as 12 per cent are considered satisfactory. Why? We specify about 25 per cent for ordinary structural steel because we feel that smaller elongations indicate material less secure against shock and fatigue

failure as well as more difficult to fabricate, and 25 per cent is readily obtained commercially. It is hardly safe to reason by analogy from steel, for we have to do with an entirely different material. This is clearly shown by the age-hardening properties of duralumin, which make the practical difficulties of its fabrication so different from those of steel. By lowering the specified elongation of duralumin to 12 per cent, material is now furnished for special purposes up to 75,000 lb. per sq. in. tensile strength instead of 55,000 to 65,000 lb. per sq. in. which was formerly considered the best that could be furnished commercially.

These newer, higher strength alloys with lower elongation, developed to meet specific demands, introduced and used with many misgivings, have so far proved to be satisfactory in service. It is still too soon to predict the ultimate judgment which will be passed on them.

Could elongations even lower than 12 per cent be specified with safety? Who can say?

A new material, however desirable its qualities, must thus pass through a period of probation before designs are worked out which will use these properties to the best advantage. In this probationary period structural tests furnish one of the most valuable aids to rapid progress. Even materials which have been much longer known and used, have as yet not wholly passed this probationary period, so that structural tests on so well-known a material as ordinary structural steel are still teaching us how it may be used to better advantage.

STRUCTURAL TESTS

In principle the structural test differs markedly from the materials test. In the materials test the object is to study the behavior of the material under the action of known stresses. In the structural test the object is to study the behavior of a given structure or structural part under the action of known loads, usually approximating those it is designed to be subjected to in service. In their practical carrying out no such distinction can be drawn, and they grade insensibly one into the other. The known stresses are produced in the materials test specimen by the application of a known load to a given shape of the material. The shape of the specimen and the character of the load are so chosen as to produce the desired stress. Obviously if a structure is so shaped and loaded as to have the same stress as in the materials test, the structural test is a materials test as well. A tensile test of a piece of wire or belting, for instance, is either a materials or a structural test, depending upon the viewpoint.

In testing practice the difference lies chiefly in two things. First, in structural testing, the size and shape of the specimens and type of loading cannot be changed at will, but are determined by considerations of design. The loading devices may thus have to be much larger and more powerful, as well as more complex, than is necessary in materials testing. Second, a major feature of the test may be the determination of the stress and strain distribution in the structure, necessitating an elaborate provision of strain gages. In an investigation of riveted joints for the Bureau of Construction and Repair of the Navy Department, fourteen sensitive optical strain gages, as well as a number of other measuring devices, were used on a single test specimen. In an investigation of girders for the U.S.S. Shenandoah 81 dial micrometers were used on a single test specimen.

MODEL TESTS

Obviously the size of the available testing machines, as well as the large cost, sets a practical limit to the size of structures which can be tested. Model tests offer in many cases a possibility of effectively overcoming this limitation. From the law of similarity we know that if geometrically similar structures of different sizes, fabricated in all their details of identical material, are subjected to geometrically similar static load distributions, the stress and strain distributions will remain geometrically similar even beyond the elastic range and up to failure of the structures. We can, therefore, reason directly from a model to a structure of any size. Unfortunately, simple as this theory is, its practical application is beset with difficulties. No large structure is formed of homogeneous materials. Rolled plates and angles vary in properties over their cross-section and the law of this variation is different for different sizes, and is different for different portions of the ingot from which they are rolled. The rivets or welds with which they are united are of different quality from the rolled sections which they hold together and this difference is often important for the success of the structure. It is, if not impossible, at least extremely difficult to choose materials for small rivets which will show the same properties after cooling as the large rivets. It is also practically impossible to produce small welds with the same physical characteristics as larger welds. The technical limits of accuracy in fabrication also set a limit to the size of a structure which can be reproduced in detail in a model of convenient size. In so far as these differences in detail are of significance in the behavior of the structure, model tests have only a limited field of application. This may be illustrated by the investigation of

riveted joints carried out for the U. S. Navy. The whole problem here lay in the most economical choice of rivet material and rivet arrangement in the use of the newer high-strength ship plates. As our largest tension machines have a capacity only slightly over a million pounds, we can, in a full-size specimen, test a row only four or five rivets long. The stress distribution in so short a row will certainly be different from that in a corresponding part of a row many feet long, but this uncertainty was felt to be less important than the difficulties involved in producing a comparable half or third size model. It seemed almost certain that a model, even roughly comparable, could not be produced.

In addition, the local concentration of stresses and strains in the neighborhood of structural discontinuities are often critical factors in determining the design. The measurement of these stresses and strains demands a detailed study of local deformations, which even in full-size structures often lie near the limit of sensibility of our strain gages. In the model these deformations will be proportionately smaller, requiring for their detection more sensitive devices. An optical strain gage, developed at the Bureau of Standards in connection with this riveted joint investigation, has permitted a considerable extension of the possibilities of model testing.

In its present form on two-inch and one-inch gage lengths it can be relied upon to detect consistently, deformations as small as two or three-millionths of an inch and its compactness and light weight make it probable that it can ultimately be adapted to much shorter gage lengths—perhaps as low as one-fourth inch.

If the tests are concerned merely with the behaviour of the structure within the range where the deflection of the members as a whole is practically proportional to the load, many of these difficulties of model testing, which have been pointed out, disappear, since then the details of joints need to be reproduced only in rough similarity, and built-up members can be safely replaced by solid pieces of similar shape. The strength of the parts no longer being a factor in the test, practically any piece of approximately the same material (or where the difference in Poisson's ratio is not significant, any material) will serve, since the moduli of elasticity differ but slightly for widely different qualities of material.

In addition, if the members of the structure all lie nearly in the same plane so that the stress is approximately a plane distribution, any elastic material whatever may be used, since in plane stress the stress distribution is independent of the moduli of elasticity. Much

use has recently been made of this fact in determining the stress distributions in structures (such, for instance, as massive arches) in which the mathematical treatment is difficult, if not impossible.

No discussion of model tests, however brief, would be adequate without mention of one of the most fruitful methods of model testing —optical stress analysis by the use of polarized light. Discovered over 100 years ago, its theory and the fundamental experimental methods were worked out nearly seventy-five years ago, but until the last few years it remained largely a laboratory curiosity. I need not elaborate on the remarkable developments of the last few years. Complex stress distributions in structures of complex geometrical shape—for example, a pair of meshing spur gears—are now known with a wealth of detail that twenty years ago would have been thought impossible. I merely wish to point out the relations of the method to the general field of materials and structural testing. Optical stress analysis possesses a sensibility that no mechanical strain gage can ever hope to reach. On small models it can trace out details of stress distribution around discontinuities of structure, which could only be detected in gigantic models by any mechanical strain gage we can ever hope to construct. Within its limitations it furnishes, beyond any comparison, the best method of model testing.

Unfortunately, its limitations are narrow. It requires a transparent model, and no known transparent material has a Poisson's ratio which is the same as that of any ordinary structural material. Its application to model testing is therefore limited, strictly speaking, to cases of plane stress or those which approximate plane stress, for only in such cases can we reason directly to the stress distribution of similar structures with other values of Poisson's ratio. Even were it possible to use the method in more complicated stress distributions the experimental difficulties would probably be too great to make it practical. However, by judicious use of the results of plane-stress analysis it has been possible to draw valuable, although approximate, conclusions about widely different conditions.

SERVICE TESTS

After all, "the proof of the pudding is in the eating thereof." Materials tests, design, and structural tests all look towards one goal—a structure in satisfactory service. The difficulty lies in determining what is satisfactory service. For bridges, dams, buildings and other structures whose conditions of use are fairly definite the answer is relatively simple. For other structures, especially those containing

many moving parts, the conditions of service are so diverse that no valid criterion of satisfactory service can be obtained from a single case. Two automobiles are turned out from the same shop on the same day. One is a wreck inside of a season, while the other may be still in service years later. That does not necessarily indicate that the first was not properly constructed to render satisfactory service; its condition may have been due to gross abuse. Nor does it necessarily indicate that the second was properly constructed. It may have had only a fraction of the use that should be expected of it. It is evident that in general only a statistical study of many individual service records can furnish results that are significant.

Where the finished structures remain under centralized control in use, the maintenance of reliable statistics of service is possible. Such statistics where available are a sound basis for a final judgment on all questions of the use of materials.

In the larger number of cases the use of the finished structures is in the hands of innumerable individuals under no centralized control, so that the securing of reliable service statistics is difficult, if not impossible. Also, even when available, service statistics are slow in accumulating. Where production is large, many thousands of unsatisfactory products might be put out into service before any service statistics could show the points in which they were unsatisfactory.

The service test, or—more accurately stated—the accelerated service test, is an attempt to bridge this gap. After a study has been made of all the imaginable deteriorating influences which the structure is likely to be subject to in use, an attempt is made to determine their average frequency of occurrence and their average importance in causing failure of the structure. By means of this study a program of abuse is outlined which is designed to cause failure within a time which is only a small fraction of the normal life in service. The abuse may consist of exaggerating the severity of the normal deteriorating influences of service or increasing the frequency of their occurrence, or a combination of both.

The comparative life of structures under well-planned abuse furnishes within a relatively short time a not altogether perfect but still valuable substitute for service statistics. Perhaps the best known examples of such tests are the intensified traffic tests carried out on test roads by the Bureau of Public Roads and the Highway Departments of various states. These tests are helping greatly in the improvement of road construction.

The value of such tests, obviously, depends in large measure upon

the judgment used in planning the program of abuse. Only if the test does fairly represent a proportional exaggeration of all the deteriorating influences in average service, will the test results correlate closely with service statistics.

SPECIFICATIONS

Much of the work of the materials and structural testing engineer would fail of its effectiveness if it were not crystallized into definite form for routine use. Accordingly, specifications are written.

If all were known that should be known about materials and their relations to structures, it is conceivable that specifications could be written which would meet the wholehearted approval of the manufacturer, the user, and the testing engineer. As it is, specifications represent a compromise between all three, based partly on knowledge, partly on ignorance, partly on habit, and partly on traditions of the art which may or may not be well founded. As a consequence no one is fully satisfied.

Unsatisfactory as they are we could not do without specifications. Of what use would it be to a builder to know that steel of given physical properties built into a given structure would not collapse under its load, if he had no assurance that the material furnished him had these properties? How could a manufacturer of steel be in a position to furnish satisfactory material to a builder unless the builders' requirements were so formulated as to be applicable to the control of his mill processes? Without the thousands of specifications which are intimately woven into it, modern industry could not function.

Even though we recognize that most specifications are, in many ways, unsatisfactory, there are still good specifications and poor specifications. Good specifications foster cooperation between manufacturer, user, and testing engineer in the production of satisfactory structures and their progressive improvement. They are a thorn in the side only of the man who would sacrifice quality to his own personal profit.

Poor specifications lead to endless controversy and misunderstanding even between those who are anxious to cooperate in the production of satisfactory structures.

An important part of the work of the materials and structural testing engineer is the assistance he gives in the improvement of specifications to the end that all may be good specifications. If he is called upon to write or assist in writing specifications, he must add to his testing technic much of the technic of specification writing, which is a related but distinct art.

Even if he personally does not write specifications, a testing engineer should have a clear understanding of the principles which govern specification writing so that he may recognize the difference between a good and a poor specification.

Many of our specifications would be better, many of the controversies which arise between manufacturers and users would be avoided if more testing engineers, and especially specification writers, familiarized themselves with these principles and followed them.

In 1907 the French engineer, Georges Charpy[3] whose name is familiar to all who test metals and who has contributed so much to modern materials testing technic, formulated clearly a principle which, it would seem obvious, should, so far as possible, govern all specifications.

"Toutes les conditions imposées doivent être spécifiées avec assez de netteté et de précision pour que chacune des deux parties (le producteur où le consommateur) puisse les vérifier sans ambiguité à un moment quelconque . . ."[4]

In the years that have passed since Charpy wrote these words, more and more engineers have heeded them, and specifications today are on the average far superior to those written twenty-five years ago.

Nevertheless, in a specification written in 1931 and still in use, I find the following requirements for a certain structure:

"Size, 1 in.; outside dimensions (approximate) 5 in. by $3\frac{1}{4}$ in.; weight, per dozen, 40 lb.; tensile strength (approximate) 70,800 lb. per sq. in."

Samples of this structure are sent to a testing laboratory with the request that a report be given stating whether the structure does or does not meet the requirements of the specification. What is the poor testing engineer to do? Is $5\frac{1}{2}$ in. by 3 in. approximately 5 in. by $3\frac{1}{4}$ in. or should the tolerance be set closer? Are 39 lb. or 41 lb. acceptable weights? If so, what about 35 lb. or 45 lb.? Was it the intention to set a minimum or a maximum tensile strength? Is 65,000 lb., 70,000 lb. or 75,000 lb. a sufficiently close approximation to 70,800 lb. so that he may say that it does or does not meet the requirements? As a testing engineer he knows how to determine—within all reasonable accuracy—what the dimensions are and what the tensile strength is. Must he also, in order to be competent, know what limits of dimensions or limits of tensile strength ought to be set on a structure he may never have used or even never have seen before?

[3] Charpy, Georges. *Les cahiers des charges pour la réception des matières métalliques.* Revue de Métallurgie, Mémoires **4**: 1041–1058. 1907.

[4] "Every specified requirement ought to be specified with sufficient clearness and precision, that each of the two parties, (producer or consumer) may at any time determine unambiguously whether the requirement is met."

Such a clause in a specification is an invitation to argument, dispute, hard feelings, and even litigation. It violates a fundamental principle of specification writing.

Contrast it with the following:

		Minimum	Maximum
Size		31/32 in.	1-1/32 in.
Outside dimensions	Length	4-7/8 in.	5-1/8 in.
	Width	3-1/8 in.	3-3/8 in.
Weight, per dozen		39 lb.	41 lb.
Tensile strength		70,800 lb./sq. in.	No maximum specified

This does take a little more printing ink than the other but with such requirements no testing engineer would quarrel. Whether these are suitable limits for the structure specified he might not know: he does not need to know. The limits acceptable to both producer and consumer should be set by the specification writer. He should not ask the testing engineer to exercise his talent for guessing or telepathic mind reading.

This is merely a flagrant illustration of one way in which a poor specification differs from a good one. Many more could be cited. No great technical skill is needed to banish such defects—merely a determination on the part of the writer of the specification to avoid obvious indefiniteness and ambiguity.

To search out the defects in good specifications, to change them so that their meaning is more clear, to modify the test conditions so as to make the tests cheaper without sacrifice of quality, to fit them to progressive advances in manufacturing processes, in other words to make better specifications out of good specifications—this is a task which challenges the skill of the best of testing engineers.

I cannot better end this brief consideration of specifications than by quoting again from Charpy—a master in the art of writing specifications. He lays down the following canon[5] of basic requirements of a good specification:

"Suppression de toutes les clauses vagues, ne permettant aucune vérification précise et laissant en réalité place à l'arbitraire.

"Réduction aussi grande que possible des conditions de fabrication qui peuvent, le plus souvent, être remplacées par des conditions de qualité.

"Définition minutieuse et précise de tous les essais qui doivent servir à vérifier les différentes conditions de qualité. Spécification du nombre des essais, des cas où ils pourront être recommencés.

"Etablissement d'une corrélation entre la précision des machines d'essai (et sa vérification) et la précision demandée dans les résultats des essais.

[5] CHARPY, loc. cit.

"Emploi de préscriptions combattant la fraude dans toutes ses manifestations."[6]

The last clause should not be necessary but unfortunately the specification writer dare not forget it.

CORRELATION OF MATERIAL, STRUCTURAL, AND SERVICE TESTS

The development of materials testing as an independent art was made possible by the scientific development which freed it from its intimate association with a unified process of manufacture. Only through that freedom could it become objective and quantitative. That freedom, however, is not complete and has brought with it, as every partial freedom does, not only good but bad effects. Busied with the details of testing, the testing engineer is too likely to think of the results of his tests as ends in themselves, independent of their relation to material structures in service. This tendency can only be combated by seeking continually and consciously to correlate the results of materials, structural, and service tests, one with another, and in the last analysis with statistics of service. With fuller understanding of these correlations, materials and structural testing will contribute still more to the progress of engineering. With this fuller understanding, materials testing will become more and more a science, approaching the ideal in which, from materials tests alone, the field of usefulness and serviceability of a material may, with certainty, be determined, to the end that there may no longer be pitfalls on the path from material to structure.

[6] "Suppression of all vague clauses which do not permit any precise verification, and which actually leave room for arbitrariness.

"Reduction to a minimum, of limitations on the processes of manufacture, which can usually be replaced by quality requirements.

"A meticulous and precise prescription of all the tests which serve to determine the quality. Specification of the number of tests and of the cases in which retests will be allowed.

"Specification of a relation between the precision of testing machines (and their verification) and the precision required in the results of the tests.

"Use of proper prescriptions to prevent fraud in all its manifestations."

GEOLOGY.—*Geologic reconnaissance of a region adjacent to Guantanamo Bay, Cuba.*[1]

O. E. MEINZER, U. S. Geological Survey.

PURPOSE AND SCOPE OF THE RECONNAISSANCE

This paper is based on observations by the writer during a field investigation which he made, as the representative of the U. S. Geolog-

[1] Published with the permission of the Director, U. S. Geological Survey. Received January 7, 1933.

ical Survey, for the purpose of finding a water supply for the United States naval station at Guantanamo Bay, Cuba. The investigation covered a period of six weeks in the fall of 1915, and was chiefly devoted to a detailed study of the geology of the United States reservation, which is a tract about 9 by 5 miles in extent, embracing the lower part of the bay (see Fig. 1), and to the location of well sites and the sinking of test wells on the reservation. A reconnaissance was, however, made eastward along the coast to the Imias River and up the Yateras River to Yuraguana (see Fig. 2).

The writer is indebted to T. Wayland Vaughan and C. Wythe Cooke for examining the fossils that were collected and for advice regarding the correlations of the several formations. Doctor Vaughan has recently (1932) revised the identifications of the foraminifera and corals and has kindly prepared the lists of species appended to this paper.[2]

TOPOGRAPHY

The region bordering the south coast of Cuba between Cape Maisi, at the east end of the island, and Cape Cruz, about 260 miles farther west, is in general mountainous, the principal interruption in the mountain chain being at Guantanamo Bay, 75 miles west of Cape Maisi. Near its head this large, pouch-shaped embayment is bordered by an extensive lowland plain, on the east, north, and west sides of which the mountains rise somewhat in the form of a huge amphitheater. Near its mouth the bay is, however, constricted by belts of foothills that extend toward the bay from the mountains on both sides.

The United States reservation lies on both sides of the lower part of Guantanamo Bay, the east side being the larger and having nearly all the development. There are three principal types of topography on the reservation: (1) hills and ridges with small intervening valleys, (2) terraces, and (3) lowlands, or tidal flats, more or less continuous with the extensive lowland at the head of the bay.

The principal hilly area, known as the Cuzco Hills, is in the southern part of the reservation, on the east side, and it forms the greater

[2] The fossils are described in the following publications:

COOKE, C. WYTHE. *Tertiary mollusks from the Leeward Islands and Cuba.* Carnegie Inst. Washington Pub. **291**: 103–156. 1919.

CUSHMAN, J. A. *Fossil Foraminifera from the West Indies.* Carnegie Inst. Washington Pub. **291**: 21–71. 1919. Also *The American species of* Orthophragmina *and* Lepidocyclina. U. S. Geol. Survey Prof. Paper **125**: 39–105. 1920.

VAUGHAN, T. W. *Fossil corals from Central America, Cuba, and Porto Rico, with an account of the American Tertiary, Pleistocene, and Recent European Tertiary larger Foraminifera.* Geol. Soc. Amer. Bull. **35**: 785–822. 1924. Also *Species of* Lepidocyclina *and* Carpenteria *from the Cayman Islands.* Quart. Jour. Geol. Soc. London **82**: 388–400. 1926.

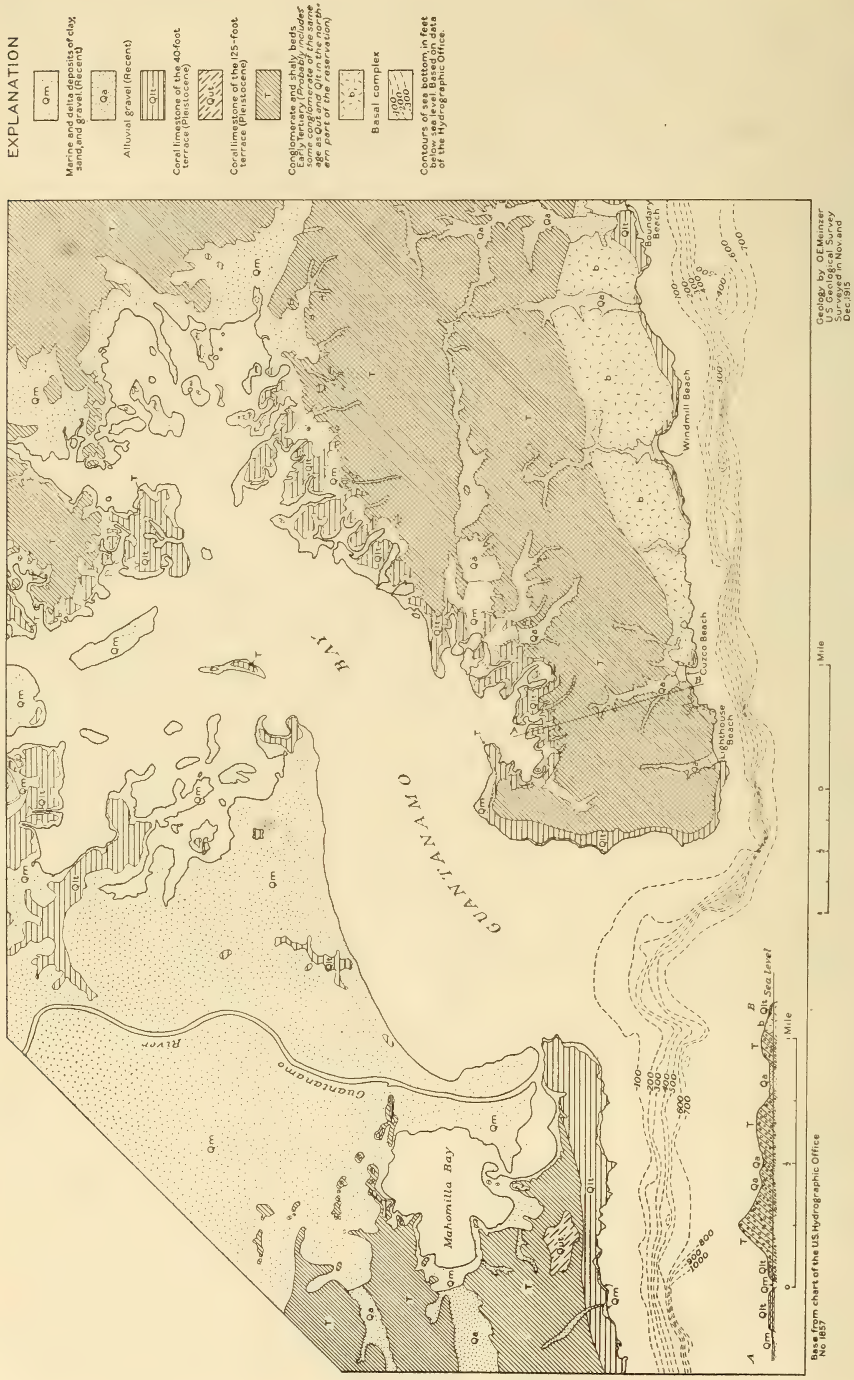


Fig. 1.—Geologic map of the U. S. Reservation, Guantanamo Naval Station, Cuba.

part of a peninsula about 5 miles long and 1 to 3 miles wide, projecting westward between the Caribbean Sea and Guantanamo Bay (Fig. 1). Its ridges, or rows of hills, trend in a direction somewhat south of west. Many of the hills rise more than 300 feet above sea level, and the highest point, known as Paul Jones Peak, is 494 feet above sea level.

There are two terraces on the reservation, which will be designated respectively as the 40-foot terrace and the 125-foot terrace, although the actual elevations vary considerably. These are described later.

The principal lowland area on the reservation is the large delta of the Guantanamo River, in the northwestern part, which has protruded into the bay, practically isolating the waters of Mahomilla Bay and the very shallow salt lake farther north. Lowlands also border the bay on the east side, forming tidal flats, especially in the reentrants of the 40-foot terrace. On the map (Fig. 1) the mangrove tracts, which are slightly below sea level, are included with the land areas.

East of the reservation the ridges assume the proportions of mountain ranges. The culminating point of Los Melones Mountains, less than 2 miles from the reservation, is 1,108 feet above sea level, and the crest lines of the other ranges immediately east of the reservation are in general not far from 1,000 feet above sea level. Farther east the mountains are still higher, many of the peaks between the Sabanalamar and Imias Rivers reaching altitudes of 2,000 to 4,000 feet. The ranges are in general more or less parallel with the coast and are separated by rather wide structural valleys. The principal streams for the most part cut across the ranges in relatively narrow valleys bordered in many places by high bluffs.

East of the reservation, between the Yateras and Imias Rivers, and no doubt still farther east, a series of terraces is well developed, not only along the coast but also in the interior structural valleys. The most conspicuous terraces are at levels of approximately 40, 200, 500, and 750 feet.

CLIMATE AND VEGETATION

The region adjacent to Guantanamo Bay has a mild, equable, oceanic climate, like that of other parts of Cuba, but, owing to the persistent trade winds and to the mountain barriers, it differs from the greater part of the island in being semi-arid. The average annual precipitation during a period of a little over three years (1912–1915) was about 17 inches. The principal rainy season is in the fall, and a

secondary rainy season occurs in the spring. The season of greatest aridity is the summer. Although the precipitation is light the humidity of the atmosphere is high, and consequently the very moderate lowering of the temperature at night is generally adequate to produce a heavy dew.

The peculiarities of the climate are reflected in the native vegetation. The region abounds in large cacti and other desert plants, not unlike those found in southwestern Arizona, but in addition it has in most places a dense growth of bushes and dwarfed trees, chiefly hard woods, forming almost impenetrable thickets. Moreover, certain tall grasses grow luxuriantly in localities that do not have any special water supply. One of the most characteristic trees of the region is a small palm, known as the yuraguana, which predominates on dry, exposed limestone ledges. The large luxuriant palms grow only along the streams and in other shallow-water areas and appear to be dependable indicators of ground water.

The high humidity and warm climate are favorable to rapid decomposition of the rocks, whereas the light rainfall provides only feeble instruments of stream transportation. Consequently the region is characterized by a great abundance of rock waste, even on steep hillsides, and good rock exposures are not common except along the coast, where the waves are effective agents of erosion.

The country between Guantanamo Bay and the Imias River is sparsely settled, resembling similar regions of rough topography and dry climate in the western part of the United States except that stock raising is carried on less extensively and less systematically. The few inhabitants of the region live near isolated springs or small streams, where they cultivate garden plots and raise a few domestic animals. As in the arid parts of the United States, the traveler must plan his itinerary with regard to available watering places.

GEOLOGIC FORMATIONS

Outline of stratigraphy

The rocks in the region examined comprise the following four divisions, arranged in the order of their age, the oldest being given first:

1. A basal complex of metamorphic and igneous rocks of unknown age.

2. Tilted beds of conglomerate, limestone, shale, and impure sandy and marly materials, several thousand feet in aggregate thickness (chiefly Oligocene; Eocene at bottom and possibly as young as Pliocene at top).

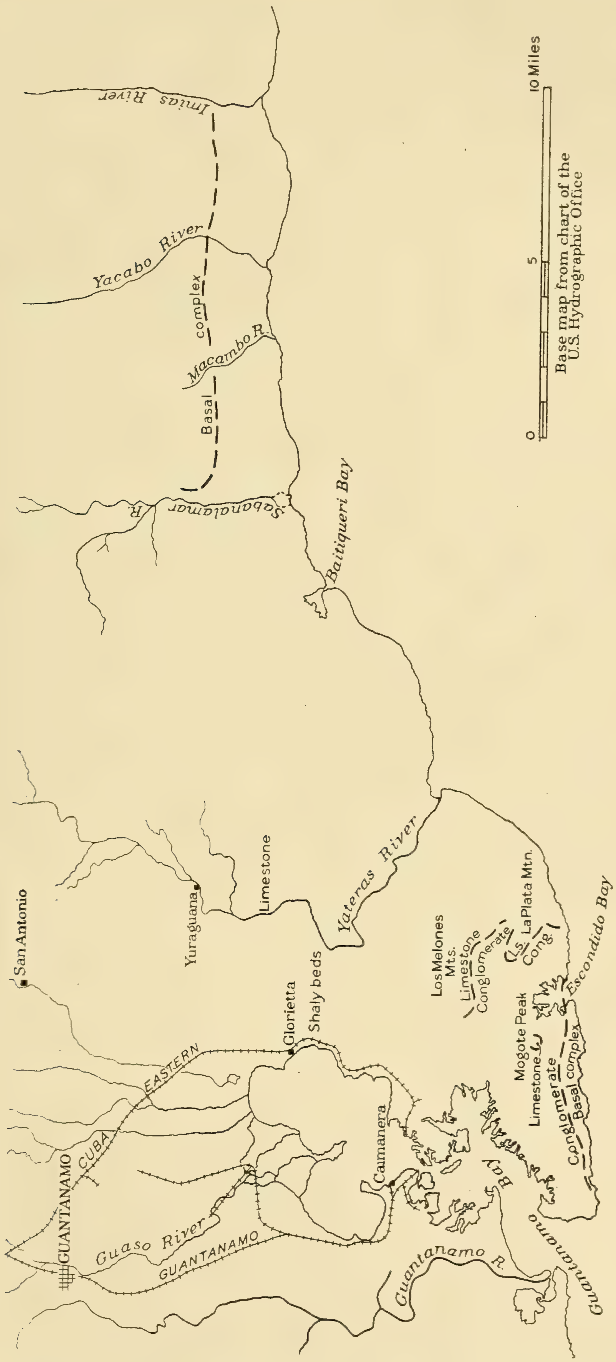


Fig. 2.—Map of the region between Guantanamo Bay and the Imias River, Cuba.
Covered in geological reconnaissance by O. E. Meinzer.

3. Horizontal beds of conglomerate and coral limestone underlying a series of terraces; probably all Pleistocene.

4. Stream gravels underlying the lower parts of the present stream valleys, and marine and delta deposits of gravel, sand, mud, and calcareous debris, at or near sea level (Recent; possibly in part Pleistocene).

Basal complex

The basal complex is the surface formation in a belt on the south side of the Cuzco Hills, adjacent to the Caribbean Sea or separated from it by only a narrow strip of limestone that forms the 40-foot terrace (Fig. 1). The best exposures are near the coast, where wave erosion has been effective. In many localities there is so much rock waste that it is impossible to determine whether the bedrock consists of the basal complex or of the conglomerate derived from it. Only at the coast is the contact between these two formations well exposed. The western extremity of the belt formed by the basal complex is about three-fourths mile east of the strait that forms the entrance to Guantanamo Bay, where the line of contact between the basal complex and the overlying conglomerate intersects the coast. From this point the belt extends eastward across the east boundary of the reservation. The basal complex was seen at several localities between the east boundary and Escondido Bay, which is 2 miles farther east, and it probably also forms the hills on the east side of the entrance to that bay. This belt, however, does not extend more than 2 miles east of Escondido Bay, and from there to the Imias River it is not exposed along the coast (Fig. 2).

A larger area of the basal complex was seen in the region between the Sabanalamar and Imias Rivers, lying 2 miles or more back from the coast and extending northward and eastward beyond the region covered by the present reconnaissance. It was examined for several miles along the Yacabo River (Fig. 2).

The basal complex is a metamorphic mass with bodies of intrusive igneous rocks. On the reservation the metamorphic mass consists chiefly of bronze-colored or dark-gray, fine-grained, slaty rock which has one set of major cleavage planes and many minor fracture or cleavage planes running in various directions, causing the rock when weathered to break into angular fragments. In several localities on the reservation the major planes were seen to be nearly vertical and to have a general east-west strike. East of Cuzco Beach they dip 75° S. 35° W. In some places, however, the cleavage planes are greatly

contorted and the formation appears schistose. True schist outcrops along the Yacabo River. In some places veins of quartz and gypsum (?) occur along the cleavage planes. The copper mines or prospect holes on the reservation are in the metamorphic rock. On the reservation only a few small bodies of intrusive rock were seen, and these consist of dark, basic crystalline rock. The abundance of boulders of this kind of rock in the overlying conglomerate indicates, however, that larger bodies must occur somewhere in the basal complex. Along the Yacabo there are intrusive bodies both of dark crystalline rock and of granite. Hard, dark, bluish limestone was seen a short distance east of Windmill Beach, but its relations were not determined.

The basal complex consists of sufficiently indurated rock to produce a rugged topography where it is exposed to erosion—the boldest and highest cliffs along the coast being in this rock. The hills which it forms in the belt on the reservation are not as high as those formed by the overlying conglomerate and limestone in the same region, but the mountains 2,000 to 4,000 feet high in the region farther east consist at least largely of the basal complex. The hills and mountains formed of these rocks are irregular, showing but little of the parallel arrangement that characterizes the hills and mountains formed by the conglomerate and limestone.

The basal complex comprises the oldest rocks in this region. In its induration and metamorphism it resembles the pre-Cambrian rocks found in many parts of the United States, but all that was definitely determined is that it is older than the conglomerate that underlies the Oligocene limestone and rests on the basal complex. Before the conglomerate was laid down the rocks now comprising the basal complex were extensively deformed and metamorphosed and then eroded to great depths.

Tilted beds of conglomerate, shale, and limestone (*Tertiary*)

Resting on the basal complex is a thick series of tilted conglomerate, limestone, shale, and various impure sandy and marly beds. These formations lie at the surface over most of the region examined.

Both in the vicinity of the naval station and in the region between the Sabanalamar and Imias Rivers hard ferruginous conglomerate rests unconformably on the basal complex and dips away from the exposed core of this complex. Near the naval station it dips northward and between the Sabanalamar and Imias Rivers it dips southward. It forms the greater part of the Cuzco Hills and outcrops in other localities on the reservation.

The conglomerate that comprises the lower part of this series is a dark brownish or reddish, dense, impervious, and thoroughly indurated formation. It has irregularities in texture but shows a definite and persistent although rude stratification. Boulders a foot or more in diameter are rare, and most of the large boulders are found near the base of the formation. Well-rounded pebbles ranging from a fraction of an inch to several inches in diameter make up a large part of the formation. The pebbles and boulders consist chiefly of slate and dark, basic, crystalline rock derived from the basal complex. Limestone pebbles were not found in the lower beds but at higher horizons the conglomerate contains limestone pebbles many of which are well rounded. On the south side of the Cuzco Hills, where wells were dug into valley fill derived from the lower beds of the conglomerate, no limestone pebbles were found, but the ridge farther north is composed of conglomerate beds in which there are numerous large and rather well-rounded limestone boulders. Many of these boulders contain fragments of fossils, none of which could, however, be identified. On the south side of Mogote Peak the conglomerate near its contact with the overlying limestone consists of well-rounded pebbles among which no limestone pebbles were found. The conglomerate in the extensive outcrops farther north and east, underlying the limestone of Los Melones and La Plata Mountains (Fig. 2), is in general non-calcareous but a few well-rounded limestone pebbles were found in it.

Resting on conglomerate at Mogote Peak and at La Plata and Los Melones Mountains there is limestone which has about the same dip as the conglomerate—generally between 10 and 20 degrees. Most of the region extending north in the vicinity of the Yateras River and east to the Sabanalamar River is underlain by limestone. Toward the north and east the dip diminishes in general until the beds lie nearly horizontal. At the mouths of the Macambo, Yacabo, and Imias Rivers the beds dip southward—away from the basal complex exposed in that region. There are many minor flexures involving some steep dips and even overturned folds, as at one locality on the Yateras, 2 or 3 miles south of Yuraguana. Faulting is suggested along the south side of Los Melones Mountains by the exceedingly precipitous south front of these mountains, and the escarpments of other ranges may be fault scarps.

The hard massive limestone that rests on the conglomerate in Mogote Peak contains fossils that are regarded by Vaughan to be of Eocene age. The fossils collected from the limestone in the vicinity of La Plata and Los Melones Mountains and farther northeast con-

tain fossils that are regarded by Vaughan to be of Oligocene age—at or near the horizon of the Antigua formation. The fossils were taken in several localities, for the most part from rock in place and some of them close to the underlying conglomerate. It was supposed in the field that the conglomerate at the base of La Plata and Los Melones Mountains was the same as that at the base of Mogote Peak and that the limestone contact was at the same horizon as that in Mogote Peak. It appears now that this conglomerate lies between the Eocene and Oligocene limestones.

In the northern part of the United States reservation the conglomerate beds give place largely to shaly beds that lie more nearly horizontal or even dip southward. A large part of the lowland north of the reservation, into which Guantanamo Bay extends, appears to be underlain by shaly and marly beds that dip at an angle of only a few degrees toward the east. An old test well, 1,400 feet deep, drilled in the northern part of the reservation went through 400 feet of alternating beds of conglomerate and shale and then through 1,000 feet of what was designated as "slaty shale," in which the well ended. East of the lowland is a conspicuous escarpment formed by limestone with some interbedded shaly strata, that rests on the main body of shaly beds. This limestone extends to the Yateras and furnished the Oligocene fossils that were collected near that stream east of Glorietta. The relation of the shaly beds to the other formations is uncertain but it seems probable that at the time of their deposition great local differences existed in the character of the sediments that were laid down.

The tilted beds that are exposed near the mouths of the Yateras, Sabanalamar, Macambo, Yacabo, and Imias Rivers differ from the formations that have been described as occurring between the naval station and the Yateras River, both in their lithologic character and in the fossils that they contain. They consist chiefly of interstratified beds of limestone and conglomerate with calcareous matrix, very different from the conglomerate already described. The limestone is in general soft and friable and in many places contains imbedded pebbles. All gradations between true conglomerate and true limestone can be found. The conditions under which these beds were formed were apparently similar to those found along the coast where calcareous debris is at present being deposited. According to Vaughan the fossils collected at several localities, especially those near the mouths of the Yacabo and Imias Rivers, appear to be of the age of the Santiago marl—an Oligocene formation younger than the Antigua formation. Fossils of possible Pliocene age were obtained in two localities from

what were regarded as tilted beds in place. Their evidence is inconclusive but points to the close of the Tertiary period as the time of the deformation of the Tertiary formations.

Terrace formations (Pleistocene)

Among the most conspicuous features of the region are the sea terraces, of which at least seven were observed at successive elevations up to about 750 feet above the present sea level. Of these, four are well developed in the region between the Yateras and Imias Rivers, and two are well developed west of the Yateras. The four east of the Yateras are at altitudes of approximately 40, 200, 500, and 750 feet above sea level—the figures for the lowest two being based on hand-level measurements, those for the upper two on rough estimates. The two west of the Yateras are at altitudes of approximately 40 and 125 feet, as determined by the topographic map and by hand-level measurements. In the vicinity of Guantanamo Bay the highest terraces are absent or indistinct. The 125-foot terrace appears to rise gradually toward the east and may be identical with the 200-foot terrace observed farther east.

The terraces generally slope gently from their landward to their seaward sides, owing both to their original grades and to the recent deposition of sediments on their landward sides. The altitude assigned to each respective terrace in this report is, as nearly as known, that of the unmodified sea bench at its landward margin, which represents approximately the level at which the sea stood when the benches were formed. Thus the so-called 40-foot terrace is in many places not much more than 30 feet above sea level, but in some places where there is alluvial wash it is considerably more than 40 feet. However, in the vicinity of the naval station, where observations were made, the terrace limestone was found near the landward margin at a maximum altitude of 40 feet, or a little more, and this altitude is therefore believed to represent about the level at which the sea stood when the terrace was formed.

The 40-foot terrace is the most persistent and best-preserved throughout the region. It occurs continuously along the Caribbean coast, a fraction of a mile in width, except where the rivers and arroyos have cut through it and in a few exposed places where it has evidently been destroyed by wave erosion. It also occurs along the shores of Guantanamo Bay, at least as far north as Caimanera, in a relatively wide but irregular belt (see Fig. 1), and it extends some distance up the Yateras and into other large valleys.

The 125-foot terrace is found on the reservation on both sides of the bay, typical remnants of it being the little mesa on which the Northeast Rear Beacon is located (Fig. 1) and the ridge south of Fisherman Point, at the north end of which the monument and flag staff are located. This terrace can also be seen in looking eastward from the bay, as far north as Glorietta. It occurs along the Caribbean coast just west of the Yateras River but was not recognized farther east.

Between the Yateras and Imias Rivers there is a persistent terrace which at Baitiqueri Bay was determined by hand level to be about 210 feet above the sea. This is the second conspicuous terrace, from the bottom, in this region, and it seems rather probable that an accurate topographic survey would show it to be continuous with the 125-foot terrace west of the Yateras, which would indicate slight tilting of the surface in the interval between its construction and the construction of the 40-foot terrace.

One terrace is definitely discernible at some undetermined level above the 125-foot terrace west of the Yateras, and two are definitely discernible above the 200-foot terrace east of the Yateras at respective altitudes roughly estimated at 500 and 750 feet. These higher terraces occur along the coast and are also well developed at points considerable distances inland, especially in the broad interior valley that is parallel to the coast but is separated from it by the line of ridges formed by the calcareous conglomerate.

The terraces consist largely of benches cut into the older rocks and are mantled with soft, massive, coral limestone. In some places, however, the smooth cut terraces are nearly bare; in others the terrace limestone rests on an irregular erosion surface; and in still others the terraces are formed by rather thick deposits of coarse gravel or conglomerate that rest on an irregular erosion surface. The deposition of the terrace limestone was at least in part contemporaneous with the wave erosion that formed the benches, just as at present similar deposits are accumulating near the shore in localities where the waves are cutting back the sea cliffs. The deposits are thickest at the outer margins of the terraces where they extend beyond the cut benches. In many places along the exposed and greatly eroded Caribbean coast the limestone underlying the 40-foot terrace can be seen resting on older formations, but along the sheltered waters of Guantanamo Bay this limestone commonly protrudes below sea level. Similar limestones were seen underlying the 125-foot terrace at the Northeast Rear Beacon, and the 200-foot and the 500-foot terraces near the

mouths of the Macambo, Yacabo, and Imias Rivers. Everywhere they rest on the bevelled surfaces of the older, tilted limestone, conglomerate, or shale, or on the irregular surfaces beyond the edges of these bevelled rock benches.

The development of the terraces in the interior valleys indicates that the present major topographic features are older than the terraces, and the great width of valleys such as that occupied by Guantanamo Bay suggests that at some time before the terraces were formed the region stood higher above sea level than at present.

That the principal terraces rank in age according to their altitudes, the highest being the oldest, is indicated by the features of stream erosion and by the precipitous cliffs that separate one terrace from another. For example, in one locality there is a rather wide ravine cut down to the 200-foot terrace, only a slight gully with a cascade in this terrace, and no erosion in the 40-foot terrace. The cliffs at the back of each terrace were evidently formed, just as the modern sea cliff has been formed, by the waves undercutting the terrace next above. The evidence is especially strong that the 40-foot terrace is the youngest. It is possible that some of the obscure terrace remnants, at levels between those of the principal terraces that have been mentioned, represent strands formed during the earlier period of progressive submergence. The principal terraces bear evidence of geologic youth, and were probably all formed since the beginning of the Pleistocene epoch. The fossils found on the 125-foot, 200-foot, and 500-foot terraces appear to be of Pleistocene age. No fossils were collected from the 40-foot terrace and none from the 750-foot terrace.

Post-terrace deposits (*Recent*)

Underlying the lower parts of most of the valleys are deposits of stream-borne gravel which constitute a more or less definite formation. These deposits are not naturally exposed but were examined in the wells that were dug. On the reservation they resemble in texture the basal conglomerate, from which they are chiefly derived, the pebbles, being imbedded in a more or less clayey matrix. The formation is not nearly so thoroughly indurated as is the conglomerate, but it is generally hard enough to require a pick for its excavation and locally it is very hard.

The lower courses of the small valleys on the reservation are relatively wide and flat, and it is only in these lower parts that the alluvial gravel has considerable thickness and assumes the character of a geologic formation. Its total thickness has not been determined, but the

width of the valleys, the slope of the rock walls, and other physiographic characteristics suggest that it probably reaches maximum depths of 50 to 100 feet in the valleys on the reservation. The wells that were dug in the lower parts of some of the valleys went to depths of only 18 to 23 feet, but there was no indication that they were near the bottom of the alluvial gravel.

There is abundant evidence that after the shelf known as the 40-foot terrace was formed the region stood higher above the sea than it does at present. The drowned character of the coast, which is manifest throughout the region can not be adequately explained by the emergence prior to the formation of the terraces, because the innumerable small bays, estuaries, and filled valleys, which constitute the principal evidence of drowning, were created for the most part by the dissection of the 40-foot terrace limestone. The width of these steep-walled valleys indicates that when they were formed the sea level was considerably lower than at present. For example, the wide valleys and reentrants that interrupt the 40-foot terrace in the vicinity of the naval station could not have been formed under present conditions, and can not be adequately explained except by the assumption of a considerable emergence above present sea level.

The chart of the U. S. Hydrographic Office shows that adjacent to the Caribbean coast there is a submerged bench, or possibly a series of benches, 100 feet or less below the present sea level and with an average width of about one-third mile (Fig. 1). It seems probable that this submerged bench was formed in the same manner as were the benches that are now above sea level. An emergence of the amount indicated by it would account very well for the width of the valleys in the 40-foot terrace, and the time required for the sea to form the submerged bench would appear to be about adequate for the erosion of these valleys. When the submergence to the present level took place the excavated lower parts of the valleys were filled, chiefly with rock waste washed down from the tributary hillsides and mountain slopes. Deposits of gravelly rock waste also occur in the upper parts of the valleys and mantle the uplands in many places but in these situations the deposits are generally not thick and do not constitute a definite formation.

Since the last submergence the land has stood at the present level relative to the sea for a considerable time, as is shown by the existence of a well-developed bench at sea level and by the aggradation of streamways in their lower courses. On the Caribbean coast the sea bench is in part cut into the rock at exposed salients and in part con-

sists of beaches and beach bars built across the mouths of reentrants. Gravelly bars extend almost entirely across the estuaries at the mouths of the Yateras, Yacabo, and Imias Rivers. On the shores of Guantanamo Bay the bench is represented by tidal flats that extend into the reentrants in the 40-foot terrace and by the large delta of the Guantanamo River (Fig. 1). Corals and other lime-secreting organisms are at many places producing a deposit of calcareous material similar to the deposits that cap the terraces.

SUMMARY OF GEOLOGIC HISTORY

The geologic events in the region adjacent to Guantanamo Bay can be summarized as follows:

1. Deposition of the materials, probably chiefly sedimentary, that compose the present metamorphic rocks.

2. Deformation and metamorphism of these deposits and their intrusion by magmas that formed both granitic and basic crystalline rocks.

3. Extensive erosion.

4. Deposition of large quantities of gravel, finer clastic sediments, and calcareous debris that formed limestone. Submergence at least during the limestone deposition.

5. Deformation and emergence.

6. Erosion, resulting in the excavation of the principal valleys now in existence, some of them probably below the present sea level.

7. Submergence of the land to a level several hundred feet above the present shore line.

8. Successive stages of emergence and probably slight tilting of the land, alternating with stages of quiescence—the emergence bringing the shore line to a level approximately 100 feet below the present shore, and permitting stream erosion below the present sea level; the stages of quiescence resulting in sea benches and cliffs at several levels.

9. Submergence to the present level, resulting in the drowning of the lower parts of the stream valleys and in the production of innumerable estuaries, bays, and coves.

10. Filling of the submerged valleys and development of a new sea bench by destructive and constructive processes.

Appendix

Report on species of fossils collected in Cuba by O. E. Meinzer in November and December, 1915

By T. Wayland Vaughan

(The numbers refer to the station records at the National Museum)

7522. South side of Mogote Peak. Altitude about 375 feet. About two-thirds way up from the base. Fossils from limestone in place and from drift. *Astrocoenia guantanamensis* Vaughan; *A. meinzeri* Vaughan; *Trochoseris meinzeri* Vaughan; *Diploastrea crassolamellata* (Duncan)?; *D. crassolamellata* var. *magnifica* (?); *Discocyclina* (*Discocyclina*) *pustulata* (Cushman); *D.* (*Asterocyclina*) sp.; *Lepidocyclina* (*Lepidocyclina*) n. sp.; *L.* 2 n. sp. *Gypsina globulus* Reuss; *Carpenteria;* Nullipores. Eocene.

7521. Top of Mogote Peak, ½ mile east of U. S. Reservation and ¼ mile south of Monument H4. Altitude about 520 feet. Limestone in place. *Lepidocyclina* sp. not identified; *Gypsina* sp.; *Carpenteria;* Nullipores. Doubtful but may be Eocene.

7523. South side of Mogote Peak. Altitude about 250 feet. About one-third way up from the base. Fossils from drift near contact between limestone and underlying conglomerate. *Astrocoenia decaturensis* Vaughan; *Goniopora decaturensis* Vaughan. Oligocene.

7506. Short distance west of Ocujal Spring (which is about 4 miles nearly due east of Monument H6, on the east boundary of the reservation). Altitude 200 to 250 feet. Limestone at contact with the underlying conglomerate. *Diploastrea crassolamellata* (Duncan). Oligocene.

7508. Canyon west of Ocujal Spring. Altitude about 200 feet. Limestone at contact with conglomerate at the top of a large outcrop of conglomerate dipping 10° to 15° northeastward. *Antiguastrea cellulusa* (Duncan). Oligocene.

7511. Along trail between Ocujal Spring and Palma, near summit. Altitude about 500 feet. Corals in drift. *Cyathomorpha tenuis* (Duncan). Oligocene.

7512. Ocujal Spring; gully south of house at spring. Altitude about 250 feet. Limestone just above contact with the underlying conglomerate. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman; *L.* (*Eulepidina*) *favosa* Cushman; *L. gigas* Cushman; *L.* sp., a stellate species; *Globigerina* sp. Oligocene.

7513. About three-fourths mile east of Ocujal Spring, short distance northeast of point where Palma trail joins the main Ocujal trail. Altitude about 300 feet. Limestone near contact with conglomerate. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman; *L.* (*L.*) *yurnagunensis* var. *morganopsis* Vaughan, n. var.; *L.* (*Eulepidina*) *favosa* Cushman; *L. gigas* Cushman; *L.* sp., a stellate species; *Gypsina globulus* Reuss; *Carpenteria americana* Cushman; *Globigerina* sp. Oligocene.

7514. One and one-half miles east-southeast of Ocujal Spring; about midway between summit and main trail. Altitude about 400 feet. Taken from the drift. *Pocillopora guantanamensis* Vaughan; *Pironastraea antiguensis* Vaughan; *Cyathomorpha antiguensis* (Duncan); *C. tenuis* (Duncan). Oligocene.

7516. West end of Los Melones Mountains, about $2\frac{3}{4}$ miles east of boundary of U. S. Reservation, and about $\frac{1}{4}$ mile north of Monument H7. Altitude 1,000 to 1,100 feet. Limestone dipping 12° N. 55° E. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman; *L. yurnagunensis* var. *morganopsis* Vaughan, n. var.; *Globigerina* sp.; Nullipores. Oligocene.

7518. South side of Los Melones Mountains, near west end. Altitude about 450 feet. Limestone near contact with underlying conglomerate. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman; *L.* (*Eulepidina*) *favosa* Cushman; *Carpenteria americana* Cushman; Nullipores. Oligocene.

7519. Landslide on south side of the range next north of Los Melones; 3.3 miles east and 0.7 mile north of northeast corner of U. S. Reservation (Monument H9). Altitude 800 to 900 feet. From drift near top of landslide. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman; *L.* (*Eulepidina*) *favosa* Cushman; *Globigerina* sp.; Nullipores. Oligocene.

7543. East side of Yateras River, about south of Yuraguana and east of Glorietta. Limestone with few conglomerate beds, dipping 5° S. 75° E. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman; *L.* (*L.*) *yurnagunensis* var. *morganopsis* Vaughan, n. var.; *L.* (*Nephrolepidina*) *undosa* Cushman; *L.* (*Eulepidina*) *crassata* Cushman (?); Nullipores. Oligocene.

7548. Flexure in rocks on west side of Yateras River, about $2\frac{1}{2}$ miles south of Yuraguana. Short distance above stream level. From folded beds near contact between conglomerate and shale with overlying limestone. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman; *L.* (*L.*) *yurnagunensis* var. *morganopsis* Vaughan, n. var. Oligocene.

7552. West side of Yateras River, about 6 miles above its mouth. Altitude about 250 feet. Rock in place at shale-limestone contact. Dip 30° N. 80° E. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman; *L.* (*L.*) *yurnagunensis* var. *morganopsis* Vaughan, n. var.; *L.* (*Nephrolepidina*) *undosa* Cushman; *L.* (*Eulepidina*) *favosa* Cushman; *L.* (*E.*) *gigas* Cushman; *Operculinella* sp.; Nullipores. Oligocene.

7553. Same as No. 7552. Altitude about 150 feet. From rock that is displaced but of local origin. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman; *L.* (*L.*) *yurnagunensis* var. *morganopsis* Vaughan, n. var.; *L.* (*Nephrolepidina*) *undosa* Cushman; *L.* (*Eulepidina*) *favosa* Cushman; Nullipores. Oligocene.

7554. Same as No. 7552. Altitude about 150 feet. Probably taken from the shale-limestone contact. *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman; *L.* (*L.*) *yurnagunensis* var. *morganopsis* Vaughan, n. var.; *L. gigas* Cushman; Nullipores. Oligocene.

7544. Yateras River, at rapids, short distance downstream from No. 7543. Stream gravel. *Orbicella imperatoris* Vaughan. Miocene (?).

7531. Less than 1 mile west of mouth of Imias River and less than 1 mile southeast of village of Imias. On south flank of ridge, facing Caribbean Sea. Altitude, perhaps 400 feet. Limestone below the conglomerate deposits, dipping 20° S. 20° E. *Goniopora* sp.; *Porites astreoides* (Lam.) *Goniopora* is Oligocene or Miocene; *Porites astreoides* is Recent or Pleistocene, probably surface rubble.

7537. West side of Yacabo River near mouth. One-eighth mile north of south edge of 500-foot terrace. Altitude perhaps 150 feet. Coral in cave, attached

to tilted beds. *Dichocoenia stokesi* (M. Edw. and H)?; *Pecten* n. sp. Probably Pliocene or Pleistocene.

7539. East side of Yateras River near mouth. Altitude near sea level. Large fossil from drift but apparently belonging to conglomerate. Small fossil apparently in conglomerate ledge. Conglomerate dips 28° N. 30° E. *Maendra labyrinthiformis* (Linn.). Recent. *Pecten* n. sp. This may be Pliocene.

7532. Less than 1 mile west of mouth of Imias River and less than 1 mile southeast of village of Imias. On south flank of ridge, facing Caribbean Sea. On 500-foot terrace near base of next higher terrace. Altitude probably between 400 and 500 feet. Fossils found in the drift. *Orbicella cavernosa* (Linn.)?; *Orbicella annularis* (Ell. and Sol.); *Maeandra strigosa* (Dana). Recent or Pleistocene.

7534. On west side of Yacabo River near its mouth. Near edge of 200-foot terrace. Altitude about 200 feet. Limestone capping the terrace. *Dichocoenia stokesi* (M. Edw. and H)?; *Orbicella annularis* (Ell. and Sol.); *Orbicella cavernosa* (Linn.)?; *Maendra strigosa* (Dana). Pliocene or Pleistocene.

7529. Less than 1 mile west of mouth of Imias River and less than 1 mile southeast of village of Imias. On south flank of ridge, facing Caribbean Sea. Altitude nearly 200 feet. Terrace limestone, in place at outer edge of 200-foot terrace. *Orbicella annularis* (Ell. and Sol.); *Maeandra labyrinthiformis* (Linn.); *Maeandra strigosa* (Dana). Pleistocene.

7525. U. S. Naval Reservation, west side of bay, at Northeast Rear Beacon. Altitude 125 feet. Fossils from limestone capping the 125-foot terrace. *Orbicella annularis* (Ell. and Sol.); *Maeandra* sp.; *Manicina gyrosa* (Ell. and Sol.); *Siderastrea siderea* (Ell. and Sol.); *Acropora palmata* (Lam.); *Porites astreoides* (Lam.). Pleistocene.

Notes: The orbitoidal foraminifera in Nos. 7512, 7513, 7516, 7518, 7519, 7543, 7548, 7552, 7553, and 7554 are all of approximately the same horizon in the Oligocene. This horizon is represented in Antigua, Jamaica, Cayman Brac, the State of Vera Cruz in Mexico, and at other localities in the Caribbean and Gulf of Mexico regions. No. 7531 is probably, in part at least, Miocene; Nos. 7537 and 7539 may be Pliocene; Nos. 7532, 7534, 7529, and 7525 are all probably Pleistocene.

PALEONTOLOGY.—*A new mollusk from the Chadron formation (Oligocene) of Nebraska. (1) Occurrence and associations.* HAROLD J. COOK, Agate, Nebraska. *(2) Description.*[1] W. C. MANSFIELD, U. S. Geological Survey.

(1) OCCURRENCE AND ASSOCIATIONS

In the course of studies along the Cretaceous-Tertiary contact in northern Sioux and Dawes Counties, Nebraska, the writer, in 1918, noted a rather richly fossiliferous exposure of the Chadron formation, the lower part of the White River group, at a locality eight miles north of Crawford, Nebraska. He has visited the locality many times

[1] Received January 17, 1933.

since then, and each visit has been rewarded by interesting discoveries, including both vertebrate and invertebrate fossils. Descriptions of some of the new mammals are now in manuscript, but a number of forms are still unstudied. The mammals so far identified from this site are as follows:

Carnivora (Creodonta), Hyaenodontidae: *Hyaenodon* sp. Carnivora (Fissipedia), Canidae: *Daphaenus* cf. *D. dodgei* Scott, *Daphaenus* sp., *Cynodictis* sp. Felidae: *Dinictis* sp. Rodentia, Leporidae: *Palaeolagus* sp. Perissodactylia, Hyracodontidae: *Hyracodon* sp. Rhinocerotidae: *Subhyracodon* sp. Equidae: *Mesohippus celer* Marsh, *Mesohippus* sp. Titanotheridae: *Megacerops* cf. *M. dispar* Marsh, *Menodus* sp. Artiodactylia, Elotheridae: *Archaeotherium* near *A. mortoni* Leidy, *Archaeotherium* sp. Suidae: *Perchoerus minor* Cook (type locality). Merycoidodontidae: *Merycoidodon hybridus* Leidy, *Merycoidodon bullatus* Leidy, *Merycoidodon* sp. Hypertragulidae: *Hypertragulus* sp. indesc., *Leptomeryx* sp. Protoceratidae: Gen. et sp. indesc. Camelidae: *?Poebrotherium* sp.

The fossils occur in the lower half of the Chadron formation, a few feet above its contact with the Pierre shale (Upper Cretaceous). In the immediate vicinity of the exposure only the lower part of the White River deposits and the uppermost part of the Pierre shale are exposed. The bedding planes of the units are practically parallel and both are tilted to the southwest at a low angle.

The Chadron formation is thin in this vicinity, from 40 to 60 feet in thickness. In the Pine Ridge Escarpment, which runs roughly east and west near Chadron, Crawford, and Harrison, Nebraska, the Chadron formation is overlain by about 500 feet of beds constituting the Brule formation, the upper part of the White River group; and this group is overlain in turn by the lower Miocene sandstone formations of the region.

The upper part of the Pierre shale, owing to long exposure before the deposition of the Chadron, is oxidized to a depth of 10 to 20 feet, and is rusty in color, though the Pierre is not weathered as deeply here as it is in South Dakota, where the weathering extends to a depth of more than 100 feet.

Though the surface of the Pierre was remarkably smooth at the time the Chadron deposits were laid down and a rather extensive mantle of coarse siliceous and granitic gravel was deposited at the contact between the two formations, as noted in a brief report published in 1922,[2] local irregularities did exist and the gravel is not everywhere present. On the gravels, and directly on the Pierre, where

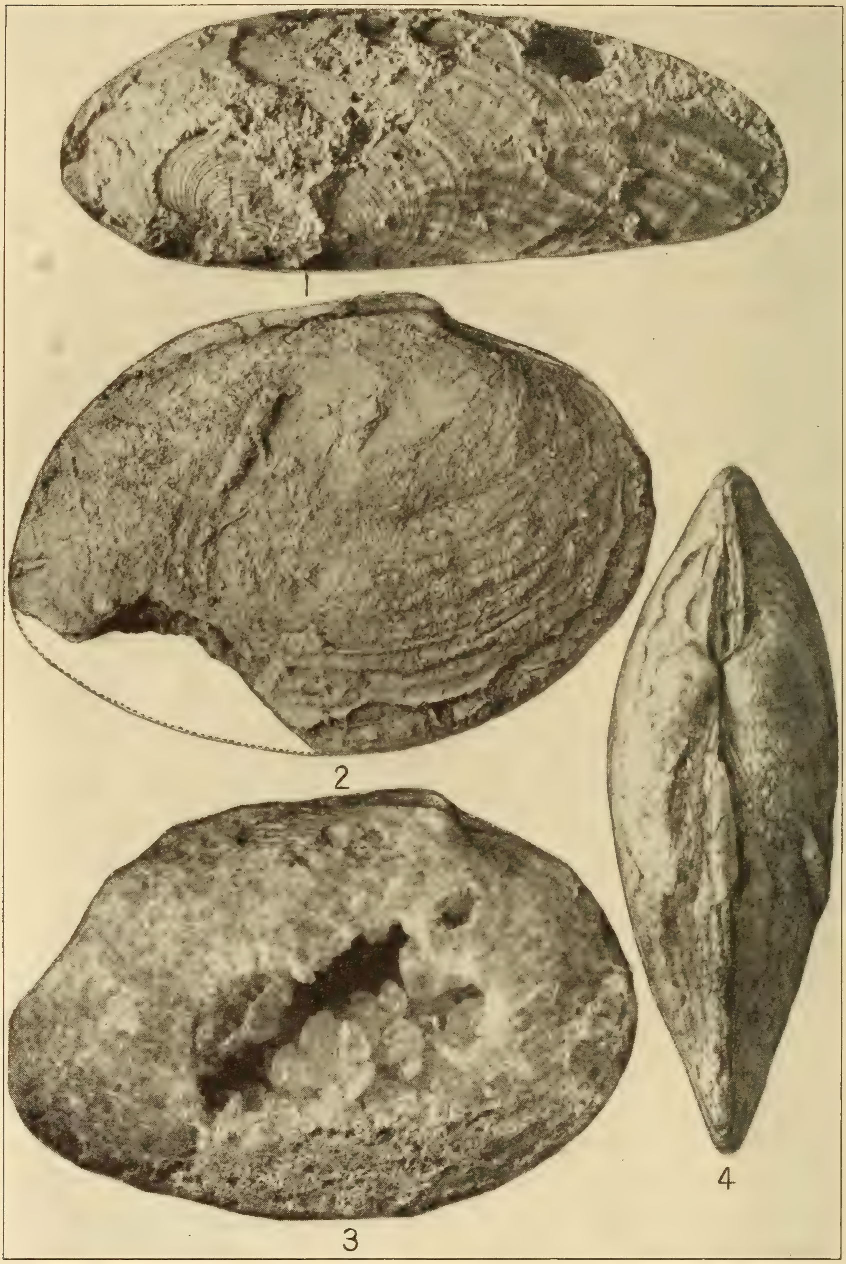
[2] Cook, H. J. *Basic Tertic conglomerate of Black Hills.* Pan-Am. Geol. 37:421–424. 1922.

the gravels are absent, lies a deposit of extremely fine grained silty clay. This clay which is generally 6 to 8 feet thick, is blue-gray to creamy gray, is very sticky and slippery when wet, and shrinks much on drying. The swelling and shrinking breaks up and destroys most of the fossils that occur in this layer and few have therefore been recovered. Chalcedony, at places so abundant as to cover the weathered surface of the beds, is present in the clay, partly as thin veins and old crack fillings, and partly as nodular masses and geodes.

By detailed studies of the Chadron sediments exposed in a shallow, rather narrow ravine the margin of an old channel was traced across the exposure. The margin is not easily seen but, once noted, can be followed without difficulty. A little coarse material, such as hardened mud-lumps, a very little gravel, a few bits of fossil driftwood, and quite a few fossil bones, generally scattered and broken, occur at intervals along the margin of the ancient channel, principally in the stream sediments. The sides of the channel sloped inward at angles between 15° and 25°. At the place where the modern ravine is cut the channel formed a bend. Near the "point" of this bend the old debris is most abundant, and here also occur groups of interesting "calcite rosette" crystals, a few of which are partly replaced by chalcedony, or partly encrusted with it. For about 50 feet along the old shore line and seldom, so far as discovered, more than 6 feet from its margin the sediments that now fill the old channel contain groups of more or less isolated mollusks, unlike, and larger than, any which I have ever encountered elsewhere in the White River Oligocene. Dr. Mansfield describes these in part 2 of this paper. The manner of occurrence of these fossils and the associations suggest that these mollusks lived in the rather quiet backwater of a sluggish lower Oligocene stream.

The mammalian fossils listed above were found by the writer and his associates, some in close association with the mollusks and others short distances away in the same levels. All specifically identifiable are typical Chadron species. The few fossil mammal remains found in the bank deposits outside the old stream bed appear, so far as identifiable, to be specifically identical with those of the channel deposits, and there is undoubtedly no significant difference in their geologic ages.

A short distance to the west, in another exposure, part of a typical stream-channel deposit is exposed, showing coarse cross-bedded sands and gravels. Along its margins also are quantities of well silicified fossil wood and fossil bones. It seems probable that the little lagoon margin where the mollusks were found was a temporary backwater along the margin of that old Oligocene stream.



Figs. 1–4.—**Lampsilus? chadronensis** Mansfield, n. sp. 1. Umbonal area of paratype enlarged three times to show character of sculpture. Cat. No. 372850, U. S. Nat. Mus.; 2. Side view of holotype, natural size; 3. Side view of paratype, natural size. Same specimen as Fig. 1; 4. Dorsal view of holotype, natural size.

(2) DESCRIPTION[3]

Lampsilus (?) **chadronensis** Mansfield, n. sp.
Figs. 1–4.

Cast of moderate size, broadly ovate to trapezoidal in marginal outline, rather compressed over the medial part of the disk. Anterior margin narrowly rounded; dorsal margin weakly arcuate; ventral margin broadly rounded; postero-ventral margin slightly produced. Beaks low and situated about 29 millimeters from the extreme anterior end. Anterior side shorter than posterior and more evenly descending to the margins. Posterior and postero-dorsal slopes steeply inclined. Sculpture, as faintly revealed on the paratype, consists of fine, closely spaced concentric lines on the beaks and heavier radials on the postero-dorsal slope.

Dimensions.—Holotype (Cat. No. 372849, U. S. N. M.): Length, 88 mm.; height, 62 mm.; thickness, 29 mm. Paratype (Cat. No. 372850, U. S. N. M.): Length, 86 mm.; height, 57 mm.; thickness, 28 mm.

Type locality.—Eight miles north of Crawford, Dawes County, Nebraska.

Horizon.—Lower Oligocene, Chadron formation.

The selected holotype and paratype are mainly internal casts of the original shells and consequently do not show some of the characters. The roughened structure on some parts of the holotype appears to represent the original shell, which has been changed in part to crystalline calcite or perhaps modified somewhat by a faintly botryoidal surface of chalcedony.

The composition of the fossil material consists of calcite alone, calcite and chalcedony, and rarely entirely of chalcedony.

The holotype and paratype are the best preserved of a lot of 14 specimens (some of which are fragments), which were received for identification from Harold J. Cook, of the Cook Museum of Natural History, Agate, Nebr. All the specimens received, except two small, elongate, and poorly preserved specimens which may belong to another genus, appear to belong to the same species as here described.

Although the hinge of the described species is not revealed, it is believed that the specimens possessed teeth, as the valves have slipped little or not at all from their original position.

Mr. Wm. B. Marshall, of the U. S. National Museum, who is an authority on the Unionidae, thinks this pearly fresh water mussel may be related to the Recent species, *Lampsilus carinata* Barnes (until recently called *L. ligamentina* Lamarck).

BOTANY.—*Morphological features of some more fungi that capture and kill nematodes.*[1] CHARLES DRECHSLER, Bureau of Plant Industry.

Four additional fungi found capturing and killing nematodes such as *Diploscapter coronatus* Cobb, *Cephalobus persignis* de Man and va-

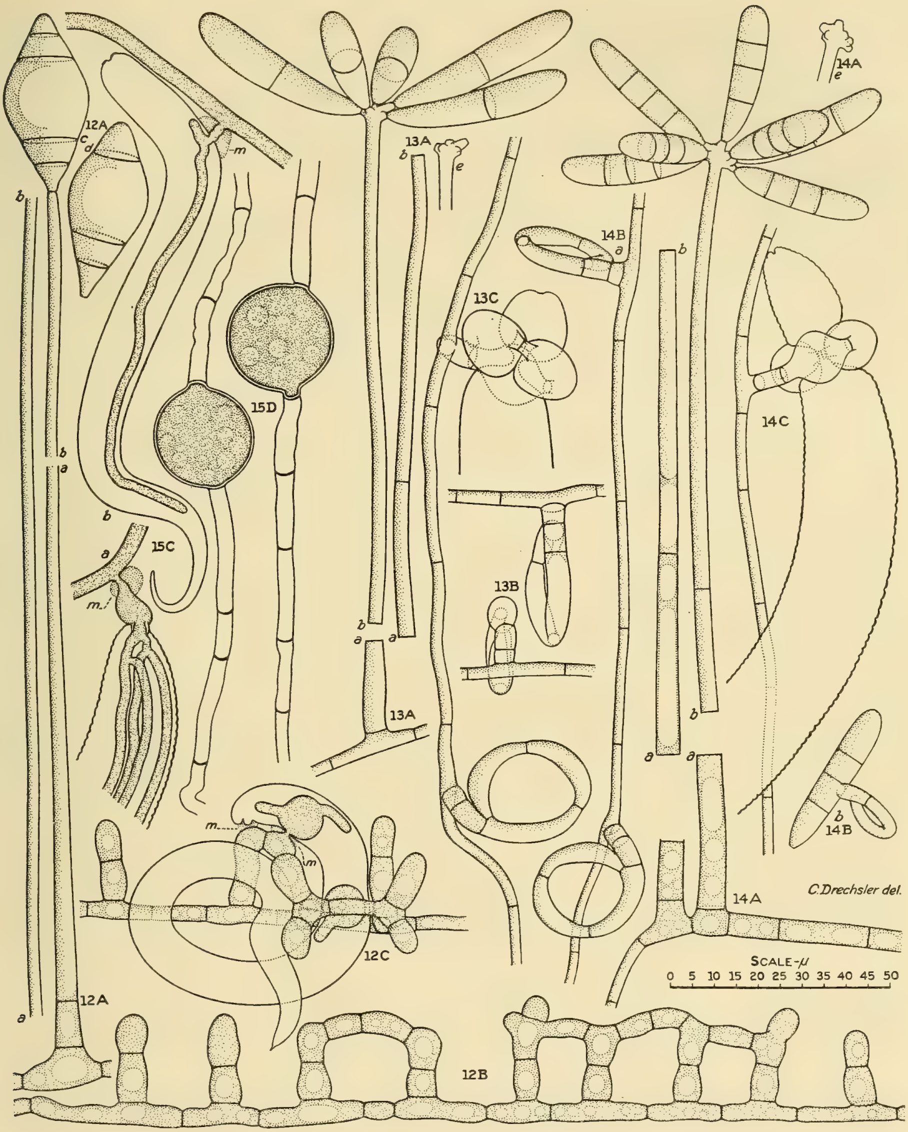
[3] Published with the permission of the Director of the U. S. Geological Survey.

[1] Received April 3, 1933.

rious forms referable to the genera *Rhabditis*, *Diplogaster* and *Bunonema*, show different degrees of morphological similarity to certain of the nema-capturing fungi noted in an earlier summary.[2] Of these four, one (Fig. 12, A) greatly resembles the fungus therein shown in Fig. 7, similarly bearing terminally mostly solitary broad fusoid spores, which are however less regularly 4-septate (Fig. 12, A, *c*), as 3-septate spores (Fig. 12, A, *d*), not greatly unlike those typical of the fungus shown in Fig. 5, often occur abundantly. The somewhat undecided condition with respect to septation is associated with the production on the surface of the substratum of apparatus of capture combining both adhesive knob-cells and hyphal loops, each of which are found unmixed in the two forms previously figured. In the form under consideration the two types of organs are less distinctly characterized, the adhesive knob-cell and its stalk being here of approximately equal diameter and together constituting a stubby two-celled process. Often such processes are produced in some number at short rather regular intervals on the same hypha, and at right angles to it, with the result that when neighboring processes become joined apically by bridging connections, hyphal loops approximately rectangular in shape result (Fig. 12, B). Further adhesive processes and closed loops may later be produced repeatedly from the anastomosing elements to yield an extensive intricate system. Killing of the animals results from the intrusion of one or more bulbous hyphal outgrowths following narrow penetration of the integument (Fig. 12, C).

In a fungus bearing terminally in rather open capitate arrangement 1-septate elongated, straight or slightly curved conidia tapering markedly toward the base (Fig. 13, A), the capture of a nema in an individual 3-celled intramatrical hyphal loop attached to the parent filament by a short 2-celled branch (Fig. 13, B), and its being killed by extreme constriction effected through pronounced swelling of the loop-cells especially toward the center of the loop (Fig. 13, C), ensues as in the fungus shown earlier in Fig. 10. Entirely similar organs of capture (Fig. 14, B) and a similar mode of killing (Fig. 14, C) are found in a vigorously predacious fungus bearing terminally in loose capitate arrangement elongated conidia with three septa so placed that the two middle cells, approximately equal to one another, are

[2] This JOURNAL 23: 138–141. 1933. As the present summary constitutes an addition to the earlier one, the numbering of the figures is made continuous through the two, so that all citations of figures given herein and bearing numerals less than 12, refer to illustrations in the earlier paper. Occasion may be taken here also to emend the opening sentence in the earlier paper by supplying the words "by various fungi,"—these to be interpolated between the words "destroyed" and "often" in the third line of the text.



Figs. 12–15.—Various nema-capturing fungi, each numeral denoting a separate species, and all species drawn with the aid of the camera lucida at the same magnification; ×580. A, Conidiophore with conidia of approximately average size, shape and condition with respect to septation; the conidiophore, because of its length being shown in several parts, *a* and *b* indicating corresponding points on these parts; *c* and *d*, spores of alternative septation; *e*, denuded tip of conidiophore. B, Organs of capture, consisting either of adhesive processes and loops (in Fig. 12), or (in Figs. 13 and 14) of constricting loops, the latter arising from vegetative hyphae (in Figs. 13, B and 14, B, *a*) or from a spore (in Fig. 14, B, *b*). C, Relation of captured animal to fungus, *a* and *b* in Fig. 15, representing separate examples, differing in place of attachment and in respect to presence of external hyphal distension; *m*, adhesive mucous substance. D, Intercalary conidia borne on creeping hyphae that have become septate on being evacuated.

noticeably inferior in length to the two end cells (Fig. 14, A). The parallelism in predacious habit of these two fungi with the fungus shown in Fig. 10, is somewhat at variance with expectations suggested by similarities in the shape of the conidium, through which articulation with the species illustrated earlier in Figs. 3 and 4 would seem indicated.

In rather moist agar plates a fungus having originally non-septate mycelium which subsequently on progressive evacuation of contents becomes often rather abundantly septate, captures nemas in large numbers, the animal being held fast on the creeping hypha by means of adhesive material appearing as a thickish sigillate yellowish pad at the place of contact (Fig. 15, C). A hyphal distension is sometimes formed outside the animal previous to perforation of the integument (Fig. 15, C, *a*), though such modification, when present, rarely approaches in size the external swelling characteristic of the fungus earlier shown in Fig. 8. Internally the mycelium shows no marked differentiation. Of reproductive bodies the fungus has so far produced only globose conidia mostly intercalary in the creeping hyphae (Fig. 15, D), the entire appearance being that of a species of Pythium.

BOTANY.—*A remarkable new* Trifolium *from Washington.*[1] C. V. Morton, National Museum. (Communicated by William R. Maxon.)

Included in a recent large collection of plants from Chelan County, Washington, received by the U. S. National Herbarium from Mr. J. W. Thompson, of Seattle, Washington, is the following remarkably distinct new species of *Trifolium.* The genus is in need of a revision, which will combine not only a study of all the available herbarium material but a thorough ecological investigation as well.

Trifolium thompsoni Morton, sp. nov.

Herba perennans, rhizomatosa, alta (usque ad 6 cm.); caules crassi, fistulosi, costati, strigosi; folia infima longe petiolata (usque ad 20 cm.), stipulis inconspicuis; folia caulina breviter petiolata, stipulis perspicuis integris petiolo adnatis; folia digitata, 7-foliolata, foliolis linearibus, apice setiformibus, margine denticulatis, strigosis; pedunculi longi (usque ad 16 cm.); capitula magna (usque 5 cm. lata), exinvolucrata; pedicelli breves, patentes vel leviter recurvi; vexillum ovale, liberum, marcescens, usque ad 22 mm. longum, non unguiculatum, apice rotundatum, mucronatum; alae longe unguiculatae, tubo staminum adnatae; carina unguiculata, tubo staminum adnata; stylus uncinatus; ovarium compressum, glabrum, carina dorsali excepta; semen compressum, laeve, glabrum.

Perennial herb about 60 cm. high, spreading by means of large horizontal

[1] Received March 20, 1933.

rhizomes; stems thick, about 4 mm. in diameter, fistulous, prominently ribbed, closely strigose (especially in the intervals), the hairs long, white, antrorse; lower leaves long-petiolate, the petiole up to 20 cm. long, about 1.5 mm. in diameter, slightly canaliculate above, white-strigose, conspicuously sheathing at base, the stipules adnate to the petiole for about 4 cm., inconspicuous, with a very short free portion; upper leaves short-petiolate, the petiole about 1.5 cm. long, the stipules very large, adnate to the petiole for about 1 cm., with a winglike, entire, free portion about 1 cm. long; leaf blades digitately 7-foliolate, the leaflets linear, the central up to 7 cm. long and 5 mm. wide, the lateral smaller, all regularly but remotely denticulate, setiform at apex, thinly strigose on both surfaces; peduncles terminal, solitary, up to 16 cm. long, similar to the stems; flower heads globose, very large (4 to 5 cm. in diameter), many-flowered, without an involucre; pedicels short (about 1.5 mm. long), spreading or slightly recurved (not reflexed), densely white-pubescent; calyx tube campanulate, oblique, about 4 mm. long, white-strigose, with very unequal setiform lobes, these all somewhat bent outward, the lower 10 mm. long, the lateral and upper about 7 mm. long; corolla standard free, marcescent, 20 to 22 mm. long, about 1 cm. wide, oval, concave, sharply keeled on the back, broad at base, not at all clawed, rounded and mucronate at apex, entire, glabrous; corolla wings about 17 mm. long, the claws long (about 1 cm.), adnate below to the staminal tube, the body elliptic, about 7 mm. long, 2.5 mm. wide, acute at apex, bearing a small spur at the adaxial base; corolla keel about 16 mm. long, the claws free above, more or less adnate below to the staminal tube, about 1 cm. long, the body semioval, about 2.5 mm. wide; stamens connate into a sheath about 1 cm. long, the free uniform filaments variable in length, about 3 mm. long, the anthers small, about 0.75 mm. long; style about 1 cm. long, uncinate, glabrous; ovary included in the standard, about 7 mm. long, lenticular, much flattened, almost straight ventrally, semi-annular dorsally, glabrous except along the dorsal ridge, about 3-ovulate, only 1 seed developing; seed reddish-yellow, much flattened, more or less square in outline, about 2.5 mm. long, the testa smooth, glabrous.

Type in the U. S. National Herbarium, no. 1,566,403, collected in dry places (sagebrush slopes) near the mouth of Swakane Creek, Chelan County, Washington, June 23, 1932, by J. W. Thompson (no. 8467). A duplicate is in Mr. Thompson's private herbarium.

The present species is one of the most remarkable plants discovered in the United States in recent years, and it gives me great pleasure to name it for Mr. J. William Thompson, whose industry and enthusiasm in botanical collecting have added so much to our knowledge of the flora of Washington. In height, in length of petiole, in size of the 7 leaflets, and in its very large flower heads and individual flowers, *Trifolium thompsoni* is without a rival in the genus. It seems, indeed, peculiar that such a large and conspicuous plant could have escaped the attention of previous collectors. Inasmuch as it is apparently not closely related to any other species, either native or exotic, it may be referred to the following new section:

TRIFOLIUM, Sect. **Thompsoniana.** Herbae perennantes, rhizomatosae, altae; folia longe petiolata, 7-foliolata, foliolis linearibus, strigosis; pedunculi longi; capitula magna, exinvolucrata; flores pedicellati, omnibus partibus magnis.

Type species: *Trifolium thompsoni* Morton.

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

American Chemical Society.—The American Chemical Society held its spring meeting in Washington, March 27 to 31, with a registered attendance of 2,293. Approximately 500 papers were listed on the program, of which a considerable number were presented by Washington chemists.

A special feature of the meeting was the observance of the second centenary of the birth of Dr. Joseph Priestley.

Prominent place on the program was given to a group of four general addresses delivered Monday afternoon, March 27. These were: *Relation of chemistry to the state,* by HARRY L. DERBY of the American Cyanamide and Chemical Corporation, New York City; *Relation of chemistry to the individual,* by CHARLES F. KETTERING, Dayton, Ohio; *Relation of chemistry to other industry,* by Dr. C. M. A. STINE of E. I. du Pont de Nemours and Company, Wilmington, Del.; and *Chemistry—Its interrelations with other sciences,* by Prof. HUGH S. TAYLOR of Princeton University.

At the general meeting on Wednesday evening, March 29, Dr. IRVING LANGMUIR of the General Electric Company, Nobel laureate in chemistry, gave an illustrated address on *Surface chemistry,* which was followed by a concert by the Washington Symphony Orchestra.

The last day of the meeting, Friday, March 31, was spent at the Edgewood Arsenal, where the members were given an opportunity to inspect the laboratories and the manufacturing plants, and to witness a demonstration of various weapons of chemical warfare.

Southern Society for Philosophy and Psychology.—A case of complete colorblindness in a young man, 23, to whom all colors appear merely as varying shades of gray was reported to the meeting of the Southern Society for Philosophy and Psychology by Dr. FRANK A. GELDARD, of the University of Virginia. Although partial colorblindness, particularly for red-green, is fairly common, this complete lack of ability to distinguish colors is extremely rare, only ten cases having been previously reported in this country. Associated with the colorblindness is an acuity of vision only one-tenth of normal, extreme shortsightedness, and nystagmus presumably to avoid a partially blind fovea, the point that gives clearest vision in the normal eye. Even moderate brightness of illumination dazzles the eyes of this man and produces temporary blindness; crossing the street on a bright day is a dangerous adventure.

The meeting learned from W. C. BEASLEY, The Johns Hopkins University, that infants are not blind during their first few weeks of life. On the contrary they are able to fixate with both eyes during the first five to eight days and can follow an object visually during the first ten days.

The possibility of using motor ability tests as an aid to the diagnosis of different types of deafness was suggested by a paper by Dr. JOSEPH E. MORSH, of the Columbia Institution for the Deaf, who has been experimenting along this line with tests of tapping, steadiness, balancing, and eye-hand coordination. The fact that the deaf are superior on speed of the hand in tapping may point to vocational possibilities.

George Washington University School of Medicine.—The fifth lecture to the faculty and students of the School of Medicine, The George Washington University, in the Smith-Reed-Russell Society series was given on March 16 by Dr. MAURICE C. HALL, Chief of the Zoological Division, Bureau of Animal Industry, United States Department of Agriculture. Dr. Hall's subject was *Drama Anthelmintica.* The April lecture was by Dr. WILLIAM H. HOWELL, Chairman of the Medical Division, National Research Council. Dr. Howell spoke on the *Recollections of a physiologist during the past half century.*

Faculty seminars for March have been by Professor CHARLES S. WHITE of the Department of Surgery, on *Chronic peptic ulcer in childhood;* and by Professor GEORGE B. ROTH of the Department of Pharmacology, on *The arsphenamines; Their nature and behavior.*

Catholic Anthropological Conference.—The eighth annual meeting of the Catholic Anthropological Conference was held at the Catholic University of America on Tuesday, April 18. Papers were contributed by Miss REGINA FLANNERY, the Very Rev. MAX HAARPAINTNER, P.S.M., Dr. TRUMAN MICHELSON of the Smithsonian Institution, and the Rev. JOHN M. COOPER. There was also a general discussion on *The child in primitive culture.*

Interest in aquiculture.—As an aid in stimulating interest in fisheries, biology and aquiculture, members of the staff of the Bureau of Fisheries discussed various aspects of the subject in a series of lectures presented at the University of Maryland during March. These lectures were as follows: Dr. LEWIS RADCLIFFE, *Biological relations of land and marine farming;* R. H. FIEDLER, *The commercial fisheries, their scope, development, and present value;* ELMER HIGGINS, *Fishery science, its development, problems, and applications;* Dr. H. S. DAVIS, *Aquiculture as applied to fresh water food and game fishes;* Dr. P. S. GALTSOFF, *Aquiculture as applied to marine food animals;* JOHN R. MANNING, *Technology of the fisheries and utilization of fishery products.*

Polar Year sounding-balloon observations.—Since August, 1932, the beginning of the second International Polar Year, to the end of March, 1933, the U. S. Weather Bureau has released 143 sounding balloons with meteorographs attached. Of these, 100 of the meteorographs have been found and returned. In nearly every case the balloon reached the stratosphere and frequently rose a considerable distance above its base. Of the records which have thus far been computed the maximum height reached was found to be 26 kilometers. The height of the base of the stratosphere varied according to location of the station and season of the year, the range being 8 to 16 kilometers. The distance travelled by these instruments varies from a few miles to several hundred miles, depending upon the wind conditions. A card is attached requesting the finder to forward it to the Weather Bureau Office where it was released, for which service a payment of $5.00 is made.

Occasionally the instruments are found under queer circumstances, one such being recently reported from the Dallas station. The instrument had fallen into a tree near Prescott, Ark., and was discovered by a negro who heard the clock ticking. This frightened him so that he ran half a mile to his home to get his shotgun, with the intention of returning and eliminating the mysterious and possibly Satanic visitor. A white man, however, persuaded him to modify his plans, so that the instrument and record were saved from destruction.

National Zoological Park.—The most important "new arrival" news from the National Zoological Park in a long time is the announcement of the

birth, during March, of two male jaguar cubs. This is the first time that jaguars have been bred in the Zoo. Dr. WILLIAM M. MANN, director, states that they are much more difficult to rear than leopards or some of the other cats, so that these are regarded as exceedingly valuable specimens.

Another event of unusual interest was the laying of a clutch of eggs by one of the Surinam toads in the Reptile House. However, the female shed most of them after they had been fixed upon her back; presumably they were infertile. Nevertheless the laying of any eggs by a Surinam toad in captivity is an exceedingly rare event, and worth recording.

NEWS BRIEFS

There was a meeting of the Fellows of the Textile Foundation on the morning of April 19, Wednesday, at the National Bureau of Standards. They visited the textile section's laboratories and other laboratories of the Bureau.

The first large shipment of parrots in nearly a year—40 gray parrots from West Africa—arrived at New York City on February 24, reports the Bureau of Biological Survey. Another shipment containing 90 parrots and also 10 macaws arrived from Nicaragua on March 6.

To the list of historic spots and natural wonders now under public administration as national monuments, has been added the Saguaro National Monument in Arizona, the United States Department of Agriculture has announced. The new monument was designated in order to preserve for posterity a representative stand of desert flora, including especially the Saguaro or Giant Cactus.

Announcement has been made of the formal designation and approval of the Maroon-Snowmass Primitive Area, by Chief Forester R. Y. STUART. This area is located within the Holy Cross National Forest, Colorado, west and south of Aspen, on the headwaters of Castle, Conundrum, Maroon, and Snowmass Creeks, all of which are tributaries of the Roaring Fork.

The curious vocal technique of "word swallowing" by singers has been discovered in two widely separated Indian tribes by two Bureau of Ethnology investigators. Miss FRANCES DENSMORE found it among the Seminoles, and M. W. STIRLING observed it during his recent sojourn with the Jivaros in Bolivia. Miss Densmore has also found that Choctaw Indians in Mississippi sing their dance songs without accompaniment of rattle or drum, a culture trait which they share with the geographically remote Tule of Panama.

The so-called Kansas-Nebraska horse disease has an insect vector, *Aedes egypti*, the same mosquito that spreads yellow fever. This has been demonstrated by experiments performed under the direction of Major R. A. KELSER of the Veterinary Laboratory Division of the U. S. Army Medical School.

An all-time low in smallpox incidence in the United States has been reported by the U. S. Public Health Service. During 1932, 11,168 cases were reported. As recently as 1930, there were 48,907 cases. There are indications that the low rate for this disease will be continued in the current year.

A new international flag code, for signalling between ships at sea, will be adopted by all maritime nations on January 1, 1934, the U. S. Hydrographic Office has announced. The new code irons out confusing differences that have hitherto existed.

A sensitive test for the detection of barbituric acid compounds, widely used in some of the newer hypnotic drugs, has been developed by Dr. THEODORE KOPPANYI, Dr. WILLIAM S. MURPHY and STEPHEN KROP of Georgetown University School of Medicine. Inasmuch as overdoses of barbital drugs, intentional or accidental, sometimes result seriously, the new test is expected to be of considerable clinical value.

A promising method of producing three-color photographs, involving the use of superimposed sheets of sensitized cellophane, has been developed by R. M. REEVE of the U. S. Army Medical Museum.

PERSONAL ITEMS

Dr. LYMAN J. BRIGGS has been nominated as director of the National Bureau of Standards by President Roosevelt This action continues the tradition that leadership in Government scientific work goes to scientists brought up in the service, on a strictly non-political basis. This has received emphasis in two ways: in sending up Dr. Briggs' appointment, President Roosevelt was repeating an appointment made by his Republican predecessor in office but not confirmed by the "lame-duck" Senate; furthermore, when questioned by a newspaperman, the President stated that he did not even know to what party Dr. Briggs belonged.

Dr. GEORGE W. FIELD, of Washington, delivered a lecture at the U. S. National Museum on March 21, under the auspices of the Department of Agriculture Graduate School. His subject was: *A conversation on conservation—What is conservation?*

Dr. WILLIAM E. RITTER, co-founder and honorary president of Science Service, has been awarded the degree LL.D. *honoris causa* by the University of California.

In connection with President Roosevelt's plan for the relief of unemployment, the Secretary of the Interior has appointed Director HORACE M. ALBRIGHT of the National Park Service to represent the Interior Department on the Advisory Council to the Director of Emergency Conservation Work. Fire Control Expert JOHN D. COFFMAN and Chief Engineer FRANK KITTREDGE have been called to Washington to assist Director Albright in this work and to handle the details of the conservation program developed for the national parks and monuments as well as for contact with the cooperating agencies under the program.

Mr. W. G. CAMPBELL, Chief of Food and Drug Administration, U. S. Department of Agriculture, addressed a meeting of the faculty of the Philadelphia College of Pharmacy and Science on the evening of April 4. Mr. Campbell considered the subject of the desirability of giving the Secretary of Agriculture more authority over certain standards and requirements for drug products as outlined in the United States Pharmacopoeia.

Prof. L. VEGARD, of the Physical Institute, University of Oslo, well known for his researches on the aurora, particularly on the auroral spectrum, ar-

rived in Washington on April 22. He is to present a paper before the Section of Meteorology of the American Geophysical Union on April 27. He plans later to visit various research institutions in this country and will give several lectures during his tour.

Dr. THOMAS VERNER MOORE, of the Catholic University of America, delivered a course of lectures on psychiatry and psychoanalysis during March and April, before Washington audiences.

Major LEON A. FOX, M.C., U. S. Army, discussed the possibilities of bacterial warfare in the March issue of The Military Surgeon. He concluded that "it is highly questionable if biologic agents are suited for warfare. Certainly at the present time practically insurmountable technical difficulties prevent the use of biologic agents as effective weapons of warfare."

Dr. H. C. DICKINSON, chief of the heat and power division of the Bureau of Standards and president of the Society of Automotive Engineers, left Washington on April 1 to visit the eleven local sections of the Society. His itinerary covered cities from Indianapolis to Seattle, Washington.

FREDERICK C. LINCOLN, of the Bureau of Biological Survey, on February 11 spoke on *Waterfowl problems revealed by banding operations* at the Fifth Annual New England Game Conference, held in Boston, Mass. Mr. Lincoln discussed the loss of waterfowl due to shooting and also the difficulty of restocking our waterfowl marshes with hand-reared mallards. Studies of data obtained by banding these birds, he said, show that few are subsequently recovered, indicating that there must be considerable loss from unknown causes.

Dr. MEADE FERGUSON, of the Virginia State Department of Agriculture and Immigration, and Dr. P. P. LEVINE, of the New York State Conservation Department, were recently appointed collaborators of the Bureau of Biological Survey in wild-life disease investigations.

Dr. P. S. GALTSOFF, U. S. Bureau of Fisheries, spoke on *Factors controlling the reproduction of organisms in the sea,* before an audience of graduate students and faculty members at Yale University, February 9.

Septicemia, in spite of the general impression to the contrary, is an important and relatively frequent cause of morbidity and mortality in the newborn, according to a report *Septicemia in the new born* prepared by Dr. ETHEL C. DUNHAM, of the Children's Bureau of the U. S. Department of Labor, for the American Journal of Diseases of Children.

ANNOUNCEMENTS OF MEETINGS

The Philosophical Society announces a program on May 20 by the Metallurgical Division of the Bureau of Standards on *Studies of single metal crystals* and *Metals of high purity.*

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WASHINGTON ACADEMY OF SCIENCES

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PHYSICS.—*High voltage.*[1] Karl T. Compton, Massachusetts Institute of Technology. (Communicated by H. L. Curtis.)

While there is much truth in the statement that necessity is the mother of invention, it has often been pointed out that it is far from true that necessity is the mother of discovery. Discoveries come often most unexpectedly, in the pursuit of knowledge by the curious and observant. The great background of natural phenomena which have thus been discovered form an immense reservoir from which may be drawn natural laws or combinations of phenomena which can be made to work for the solution of men's needs or desires when necessity arises.

One of the most excellent examples of the fact that necessity is the mother of invention is found in the great number of applications of science which were made during the past war to cope with situations which never before had challenged the ingenuity of man. Such situations were the detection and location of submarines or of airplanes flying by night. There were also the location of underground mining operations or of enemy artillery by sound, or the direction of counter-battery artillery fire, also by sound. Such examples could be multiplied almost indefinitely, but the interesting feature of them all is that every one was handled by the application of some scientific phenomenon which had been known in the laboratory for many years. The necessities of war brought forth the means of applying these phenomena for particular purposes.

It is to a very recent example of this natural sequence of events that I will call your attention tonight, an example taken from the field of electricity, the chosen field of Joseph Henry in whose honor

[1] The third Joseph Henry lecture delivered before the Philosophical Society of Washington on March 11, 1933. Received April 6, 1933.

this lecture has been named. It is a modern application of one of the oldest branches of electricity, a branch so old that some ultramodern textbook writers have advocated omitting it entirely from textbooks on account of the academic and impractical character of its subject matter. But let me first lay the groundwork for this new development in the field of high-voltage electricity.

While electricity can be produced in a variety of ways, and it was some time in the history of the subject before it was realized that the electricity was the same kind of thing in all of these cases, nevertheless there are but three principal means of generating electricity. The first is static electricity, first discovered by Thales of Miletus as early as 600 B.C. Thales found that amber, when rubbed against other substances, had the power of attracting fragments of straw or leaves or feathers. In fact the word electricity is derived from the Greek word electrum meaning amber, and was first so used by William Gilbert in about 1600.

The second great step in the production of electricity was the invention by Volta of the Voltaic cell in 1799, and from that time until the time of Faraday in 1831, the great development of electricity was in the production of batteries of various kinds. Volta was able to generate several hundred volts by piling up alternate layers of copper and zinc, separated by paper which had been moistened with acid thus creating, in effect, a battery with a large number of cells in series.

When in 1831 Faraday made the discovery of electromagnetic induction and about the same time Joseph Henry discovered self-induction and independently repeated a number of Faraday's discoveries in mutual induction, the modern science of electricity and art of electrical engineering were born.

It is a striking fact, which perhaps we do not stop to think about, that this so-called electrical age has grown up during a period of one working lifetime, since men like Elihu Thomson are still living and men like Edison have just died, who built upon these scientific discoveries of Faraday and of Henry the modern art of electrical engineering.

With the development of electro-magnetic devices, dynamos, motors and transformers, the use of batteries except for very special cases has largely been discontinued. Static electricity, which had been developed from the study of frictional charges and charges of conductors by induction, was relegated almost to the field of scientific but useless curiosities. The efficiency of electromagnetic generating apparatus has been developed to a remarkable degree, so that, for the

practical purposes of our industrial needs and our home needs, the modern science of electricity has appeared to be eminently satisfactory.

It is true that there have been some other new developments of first importance in the electrical field, notably electronic devices, such as radio tube detectors, amplifiers and transmitters or devices which operate with ionization of gases, such as the mercury-arc rectifier and the glow discharge tube. These things, however, are more in the nature of electrical instruments or electrical control devices and it still remains true that the production and distribution of electricity are basically carried on by means of the electro-magnetic induction devices developed from the work of Faraday and Henry.

Let us first follow the development of high voltage by electromagnetic induction. In this as in all other fields the first developments were crude, as was necessarily the case because instruments and methods had not been developed and everything had to be taken up *de novo*. When Joseph Henry wished to build his great magnet with several coils of wire, he had first to invent insulated wire, which he did by wrapping strips of his wife's dresses and petticoats with shellac around the wire. When Henry wished to measure the voltage of the current produced in a step-up transformer, he had no ammeter or voltmeter capable of detecting the small current at high voltage and had to substitute for them the students in his class, judging the voltage by the number of students who could be shocked when connected hand to hand in series across the terminals of the secondary of his transformer. Thus a voltage that would shock thirty students he estimated to be twice as high as one which would shock fifteen students, and in this way he was able to arrive at a very crude but correct idea of the relationship between the number of turns of wire in the secondary of a transformer and the voltage which was produced therein.

The story is told of a striking lecture demonstration given by Henry while at Princeton. He hung a secondary coil of a large number of turns of wire on the inside wall of his classroom and had the students of his class join hands in series across the terminal of the coil. The primary coil of this transformer was concealed from the students, being suspended on the outer wall of the building from wires passing out through an attic window and connected with a large Voltaic battery in the attic. When Henry rapped against the wall his assistant in the attic plunged the copper and zinc battery plates into the acid, thus sending a current through the primary, which induced a high voltage in the secondary and shocked the students of his class.

It is probable that Henry, burdened as he was with administrative

duties and the difficulties of finding the means wherewith to carry on his experiments did not realize so clearly as did his contemporary, Faraday, the ultimate practical value of these things which he was doing. Faraday, when once asked by the King, "What is the use of these things?" replied, "Your Majesty, of what use is a baby?" And another time when he was asked by the Prime Minister this same question, "Of what use are these things which you are doing?" he replied, "Your Excellency, some day you may be able to tax these things." Henry, however, was so wrapped up in his scientific pursuits that he gave little thought to the possible practical application of his work. It is said that when he was once urged to press his claim as inventor of the telegraph and other instruments, he replied that there were far too many interesting things to be done in the laboratory to permit him to take time with such matters.

There has been a practical urge for the development of high voltage power from three different points of view. The first and most important of these is for the transmission of electric power over large distances. It is much more economical to transmit power at high voltage and small current than at low voltage with large current because the resistance losses depend upon the current and not the voltage. For this reason, the voltage of high power transmission lines has continually risen from first a few hundred volts, then a few thousand, not many years ago sixty thousand, and now upwards of two hundred thousand volts. The losses of power due to heating of the wire from the flow of current are such that, according to a practical rule, it is not economical to transmit electrical power farther than one mile for every thousand volts. From this we see that a modern two hundred thousand volt transmission line could be economically used to transfer power from the power generating station to distances of about two hundred miles but beyond these distances such transmission of power is not economical. For that reason, in any area requiring the use of electricity, power generating stations must be located at distances of not more than two hundred miles from each other.

The question may be asked as to why the voltage is not raised still higher than two hundred thousand volts, and the answer to this is found in the fact that with higher voltages the electric field in the air surrounding the wire becomes so intense as to ionize the air, causing a leakage of electricity from the wire into the air in the form of an electric discharge known as a corona. It is this phenomenon of corona which sets the practical upper limit to the voltage which can be used for transmission.

It is not feasible to generate directly voltages in the range of several hundred thousand volts because the difficulty of insulation becomes too great, and an electric dynamo with insulation adequate to withstand even several thousand volts would have to be so large, to include the necessary insulation, as to be unwieldy and inefficient. Consequently, the power is generated at relatively low voltage, usually a few hundred volts in alternating current and this is sent through a step-up transformer insulated in oil in which the secondary has a hundred or a thousand times more turns of wire than the primary. In this secondary coil the very high voltage is generated for transmission over the power lines. Then at the other end of the line the power is fed through a similar transformer in the reverse order and comes out of that secondary as a very large current at relatively small voltage.

There has been no really fundamental difficulty to be overcome in these power transmission lines, although there have been very many interesting problems of science and engineering to be solved. The proper design of a transformer to be efficient and to be sufficiently well insulated is one problem. Perhaps the most difficult problem has been that of proper switching devices so that these high-voltage currents can be started and stopped without excessive arcing at the switches. It is such developments as these which have made the great generating stations at Niagara Falls and the many other hydro-electric or steam-electric generating stations such an important feature in our present industrial life.

The second thing which has stimulated high voltage developments of the electro-magnetic type has been the x-ray. For ordinary purposes, from thirty thousand to one hundred thousand volts are adequate for either diagnostic or therapeutic purposes. Of recent years, however, in the endeavor to find the most effective methods of treating internal cancerous growth there has been an increasing desire to go to much higher voltages and consequently x-ray tubes operating on as much as a million volts have been developed at the General Electric Company, at the California Institute of Technology, and elsewhere.

To generate the high voltage power for these x-ray tubes, recourse has been had to transformers connected in series, the primary of one transformer being connected with the secondary of the other, and all transformers after the first being insulated. By such means, large power can be delivered and high voltages obtained, although a million volts appears to be about the practical limit because there are parasitic currents known as charging currents which drain a great deal of

energy uselessly from the system when an alternating or varying current is used at such high voltages. Furthermore, the equipment becomes tremendously expensive on account of the requirements for insulation.

The third thing which has led to high voltage developments of the electro-magnetic induction type has been the study of the effect of lightning on transmission lines and the desire of electrical engineers to duplicate as nearly as possible the effect of lightning by means of high-voltage sources for laboratory study. For this purpose there has been developed the impulse generator, in which a series of condensers capable of storing electric charge at high voltage are charged in parallel from a high-voltage transformer and are then connected in series so that the overall voltage which is delivered is the sum of the voltages across the separate condensers. By such means impulsive or momentary voltages of ten or fifteen million volts have been obtained. These are exactly right for studying transient effects like those of lightning, but the impulse generator is inherently incapable of serving properly any purpose which requires a steady and reasonably constant source of high voltage. The discharge in this impulse generator lasts only a few hundred thousandths or millionths of a second.

This impulse generator represents the peak of high voltage accomplishment by the electro-magnetic method and you will notice that this is accomplished by combining with the electro-magnetic device, namely the step-up transformer, a series of condensers which are essentially electro-static instruments.

Let us return now from the high-voltage developments, based on principles of electro-magnetism, to the historically earlier type of electric generation which falls within the general field known as electro-statics. The characteristic of these devices has been the relative ease of producing high voltages, but with an exceedingly minute quantity of electricity.

The first electrical machines of which we have any knowledge were frictional electrical machines constructed about 1663 by Otto von Guricke. They consisted of globes of sulphur made to rotate about an axis so as to rub against the hands of persons held against them. In this way the globe of sulphur became electrically charged and the charge of the opposite sign appeared on the person who touched the globe. Isaac Newton appears to have been the first person to use a glass globe instead of sulphur, but it was Ramsden in 1768 who really constructed the first object which might really be called an electrical generating machine.

The Ramsden machine consists of a glass plate which can be rotated by a winch, and which passes with rubbing contact between two leather pads. By friction the glass becomes positively charged and the pads negatively charged. These positive charges are taken off the glass disk as it passes in rotation between combs of sharp points. Similarly the negative electricity from the pads is collected from them and delivered to another terminal. For a number of years the only development of the art of electrical generation consisted in finding various materials which might be put on the glass or on the leather pads to increase their effectiveness in separating frictional electricity.

A later development of a frictional machine is that invented by Lord Armstrong of Newcastle, England, in 1841. Lord Armstrong was experimenting with steam boilers. By accident one of his assistants received an electric shock when he touched a piece of metal against which a jet of steam from a leaky boiler was striking. This led Lord Armstrong to further experiments leading to the steam electro-static generator. The action of this generator consisted in blowing drops of condensed steam, by the steam pressure, out through a series of nozzles against a neighboring metal plate. The droplets of water were charged by frictional contact against the walls of the nozzles. The electrical power was created by the work done in moving the charged droplets against the electric field which developed between the nozzle and the plate on which the droplets struck, and of course this power was in turn derived from the driving power of the steam which carried the droplets out and away from the nozzle.

Another whole series of electro-static generators was built upon the principle of electro-static induction. Perhaps the simplest of these was the Belli doubler, which was devised in 1831 and operated on the same principle as a later device designed by Lord Kelvin and better known as the Kelvin Replenisher, described by him in 1872. This action is shown schematically in Fig. 1. When the rotating member with the insulated plates E and F is at the position shown, positive and negative charges are separated from the connecting wire, which brushes lightly against E and F, by means of the electro-static forces arising from the charges on the neighboring metal armatures C and D. As the rotating arm turns and breaks contact with these brushes the charges are carried on E and F and, when they touch the springs C and D respectively, these charges are communicated to the armatures, thus increasing the charge already existing on these armatures. Then at the next contact with the brushes at E and F the process is repeated. Consequently the charge on the armatures continually

builds up until it reaches such magnitude, or rather until the voltage rises so high that the charge leaks away as fast as it is produced, leaking away either through the insulation or by a corona discharge produced by breakdown of the surrounding air.

A large variety of instruments, some simple and some very complicated, have been developed to carry on the idea of the Belli doubler in a more efficient manner. Such devices were devised by Varley in 1860, by Toepler in 1865 and by Holtz between 1864 and 1880, but by far the most successful of these devices is the well-known Wimshurst machine which was first invented in about 1878. This machine is well-known to everybody, I think, as the "influence machine" whose action may be described as follows:

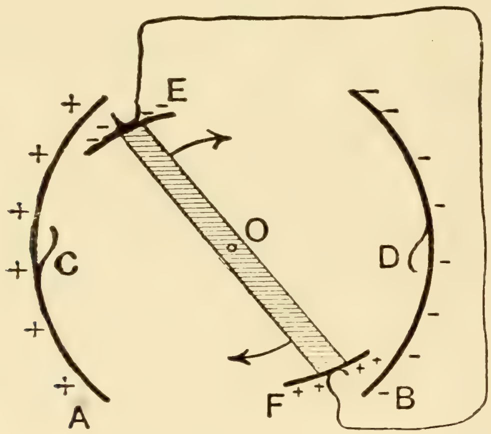


Figure 1.—Schematic diagram of Kelvin Replenisher.

Imagine that, in some way or other such as by friction, a small negative charge is located on the metal sector of the rotating disk opposite the point C of Fig. 2. This negative charge will induce the separation of positive and negative electricity in the metal rod CD, drawing positive charge to the point C and forcing negative charge to the point D. At these two points the charges are collected on the metal sectors of the second glass disk which is rotating in the opposite direction. Thus all the metal sectors to the right of C carry positive charge collected from C and they all deliver it to the sharp needle point at F.

At the same time, these positive charges on the metal sectors to the right of C will similarly induce negative charges in the metal rod AB, which charges will be deposited on the metal sector to the left

of A and will in their turn be collected by the sharp point at E. Thus the process is a continuous one, E and F collecting negative and positive electricity, respectively, from the metal sectors on both of the revolving disks. By having a multiplicity of revolving disks these Wimshurst machines may be made to deliver a considerable amount

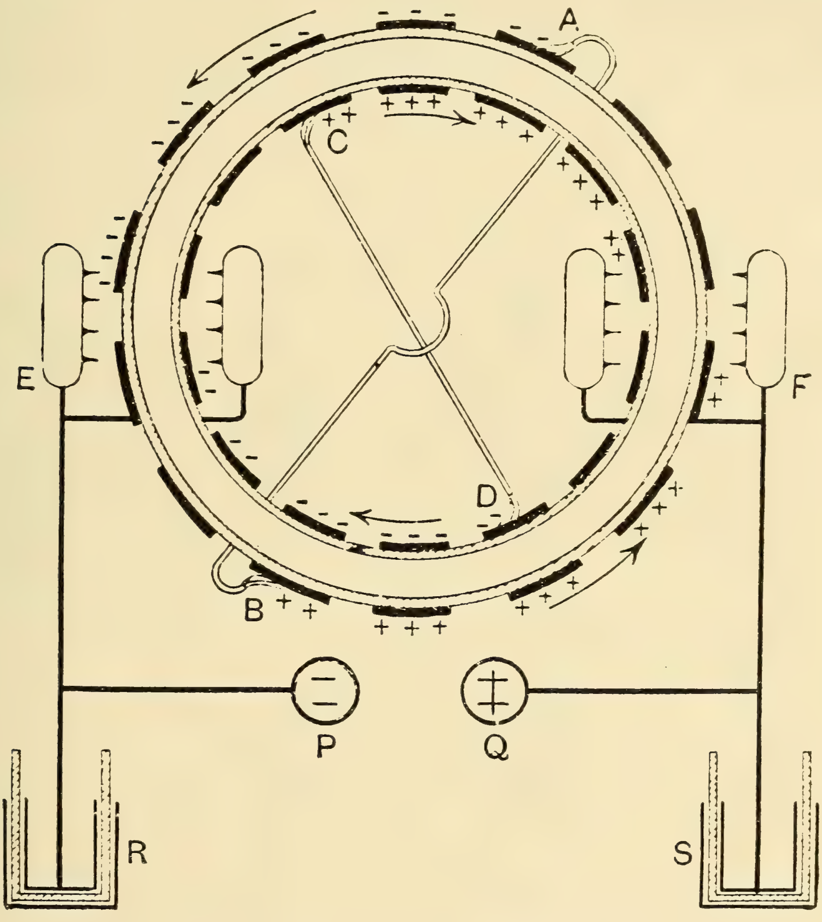


Figure 2.—Schematic diagram of Wimshurst influence machine.

of power and were in fact at one time quite largely used in the x-ray art until they were supplanted by the more powerful and much more convenient electro-magnetic induction devices described previously, including step-up transformers, induction coils and the like.

One of the most ingenious types of electrostatic induction machines is the famous Kelvin water-dropper which is shown in Fig. 3. Here

perhaps more easily than in any of the other induction machines can be seen the way in which a small charge once produced may result in the continual building up of an indefinitely large charge, if the arrangement of apparatus and connections are suitably arranged. Assume for a moment that for some cause, such as friction of the wind or anything else, there happens to be a small charge on the cylinder *A*. Every drop of water leaving the outlet in *A* will therefore carry a small induced negative charge which will be delivered to the cup below thus raising the cylinder at *B* to a negative charge. All of

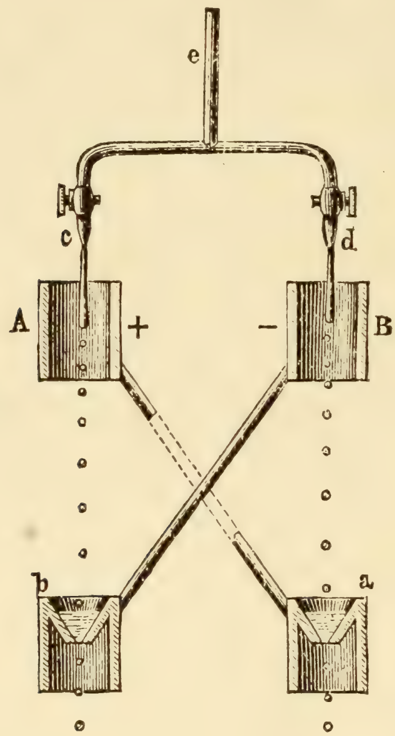


Figure 3.—The Kelvin water-dropper.

the drops of water which come from the outlet inside of *B* will therefore carry the positive charges which will be collected in the trap below and serve still further to increase the positive charge on *A*. So the process goes on, the charges building up until through leakage or through a corona discharge to the air, they leak away as fast as produced.

At this point I am minded to make a confession regarding my first experiment in physics. I conceived the idea of producing electrolysis by the use of gravitational energy alone, and set up a device some-

what similar to the Kelvin water-dropper. My device consisted of drops of copper sulphate coming from an outlet like that in the cylinder A and falling into a platinum funnel like that directly below A. I charged the cylinder A with a large negative charge from a static machine and this charge remained on the cylinder, which was well insulated. Consequently, every drop of copper sulphate which dropped carried an induced positive charge and delivered it to the funnel b which was earthed. This excess positive charge would of course be in the form of copper ions which would be deposited on the platinum in the process of neutralization of the drop. After running the apparatus for an hour or so, I looked at the platinum cylinder to see whether I could see any copper deposited on its inside and finding none I set the apparatus going in the late afternoon and let it run automatically until the following morning. Again examining the funnel, I found no deposit of copper and, somewhat surprised, I sat down to figure. I soon discovered that the copper would be present in far too small a quantity to detect. In fact, if every drop were charged with the largest amount of electricity which it could carry without losing it by corona to the surrounding air, and if the drops had fallen as fast as possible beginning with the time of Christ, I would by this time have collected barely enough copper to be shown by the most sensitive known chemical test. This little experience illustrates the vast difference in magnitude between the kind of currents that we are accustomed to deal with in electromagnetic induction devices, dynamos and motors, and these relatively very feeble currents of electrostatics. These drops were charged with high electrostatic voltage and the device was a fairly efficient electrostatic generator, and yet two thousand years would have been required to deposit an amount of copper such as would appear in a fraction of a second with only a moderate current of the type which we ordinarily use in electromagnetic instruments.

In recent years an interesting development of the Kelvin water-dropper has been proposed by Doctor Swann of the Bartol Research Laboratory in which the water drops are replaced by steel balls which fall under the action of gravity, and in order to make the process continuous, there is the suggestion whereby these balls may be carried back again to the upper container by means of magnetic control. In this way, the succession of falling balls behaves somewhat like a continuous belt containing metal sections separated by insulated regions of air and driven by gravity. In the absence of leakage this kind of a generator should be capable of developing such a high voltage

that the electrostatic attraction of the falling balls would just compensate gravity. This would be an extremely high voltage such as could be obtained only if the apparatus were operating in a vacuum, and in fact Dr. Swann suggests that it may be operated in this manner.

With this historic survey of electrostatic generators, let me now return to the text of my address, "Necessity is the mother of invention." Until very recently there was no compelling need to force physicists to seek ever higher and higher voltages in electrical-generating devices. Their needs were met by existing devices of the electromagnetic type. Within the past dozen years, however, it has become evident that a whole new range of fundamental investigation into the properties of atoms will be opened up by a suitable source of high potentials.

This new inducement may be said to have arisen with Rutherford's discovery that it is possible to transmute one chemical element into another by bombarding it by the fast electrified particles known as alpha particles which are spontaneously given off by radio-active materials in the process of their disintegration. These brilliant experiments opened up a whole range of new explorations into the structure of the atomic nucleus, and stimulated the imagination of scientists in regard to what might be done if only they had available some more powerful and better controllable source of high-speed missiles to shoot at the atomic nuclei. The alpha particles from radium do have tremendous velocities but they are relatively few in number and all the radium that could conceivably be gathered together in the world would not produce a stream of electrified particles comparable to that which can be obtained in an ordinary discharge of electricity through a vacuum tube. If only the voltage as applied to a vacuum tube could be made high enough to give the ions in a vacuum tube speeds comparable with or even exceeding those of alpha particles from radium, what a powerful attack could be made upon the nucleus! Not only could particles in billion-fold larger numbers be used, but different kinds of particles could be tried, such as hydrogen-nuclei, helium-nuclei, lithium nuclei, neon-nuclei and so forth, and these could be given any desired speed up to the maximum limit determined by the highest voltage available. So for the past dozen years, thoughts of scientists have again been turned to means for producing ever and ever higher voltages.

It was to this end that the million-volt installation at the California Institute of Technology was designed. It was also to this end that a

system of high potential transformers and condensers was built by Cockcroft and Walton in Cambridge, with which they were the first successfully to disintegrate atoms by means of electrified particles produced from an artificial source and speeded up by an applied voltage. However, the necessities of the case have led to other suggestions for securing high voltages because the inherent limitations of electromagnetic induction devices lead to prohibitive expense and complexity if voltages much above a million volts are sought by such means.

There have thus been three very interesting new developments in the art of securing high voltages, or perhaps more generally, electrified particles with those speeds which would be acquired with tremendously high voltages. Of these, in order of apparent utility, are the devices of Brasch and Lange in Germany, of Lawrence at the University of California and of Van de Graaff at the Massachusetts Institute of Technology.

The greatest natural source of high voltage of which we have any knowledge is the thunderstorm. It is estimated that the voltages in lightning flashes frequently exceed a billion volts; consequently it was natural for Brasch and Lange to look to the lightning flash as a source of high potential and to set up what may be considered as a glorified Franklin kite. Their apparatus consisted of a pair of long cables suspended between mountain peaks in that region of the Alps where thunderstorms are most frequent. These cables may be thought of as huge wireless antennae for receiving the electrical impulses of nearby lightning flashes. This was an installation of real engineering proportions since the porcelain insulators alone at each end of the cable weighed upwards of two tons. The terminals of the two conducting cables consisted of large spheres, whose distance apart could be varied by drawing in or letting out cable. The voltage obtained was estimated by the sparking distance between these spheres and voltages were obtained ranging between eight and fifteen million volts.

Although the voltage was tremendously high, its erratic occurrence and uncontrollable nature has led Brasch and Lange to give it up in favor of somewhat more conventional means of producing their high voltage, and at present they are working with an impulse generator.

An extremely clever device is that invented by Professor Ernest Lawrence of the University of California by means of which electrified particles may be given energy characteristic of several millions of volts with the application of a much smaller voltage. The principle

is that of repeated impulses, analagous to the way by which the amplitude of swing of a child in a swing may be made very great by a succession of small pushes, properly timed. In Lawrence's apparatus, an oscillating voltage is applied to the ions, first in one direction and then in the other, while they are moving in approximately circular paths in a magnetic field and conditions are adjusted so that every time the voltage is applied the electrons are speeded up by just that

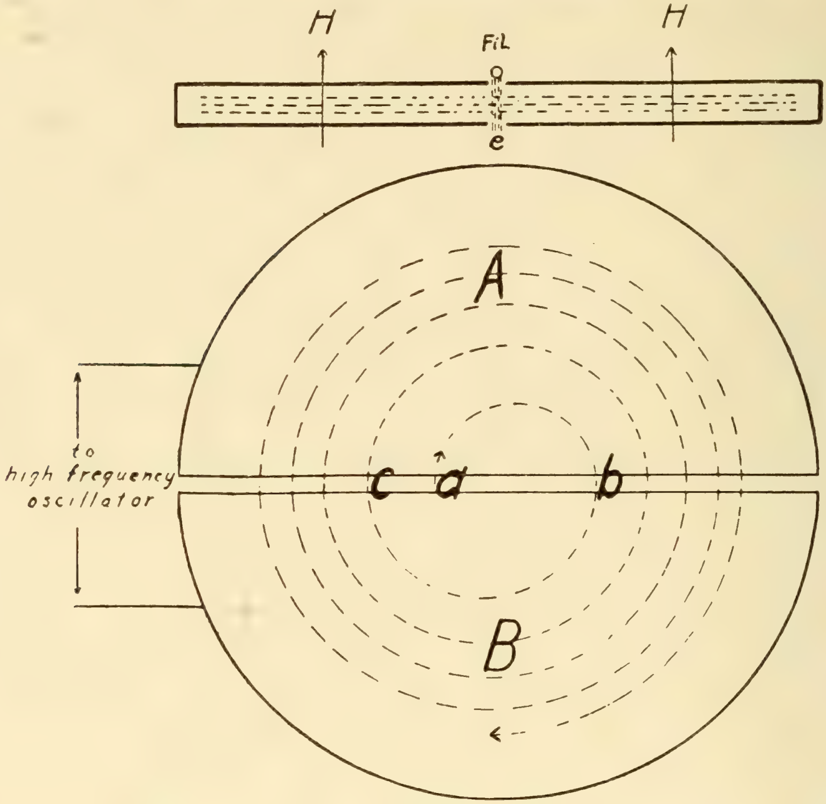


Figure 4.—Diagram of Professor Lawrence's apparatus for producing high-speed, electrified particles.

amount. Thus, by applying only a few thousand volts, protons have been obtained with energy corresponding to nearly two and a half million volts.

Fig. 4 shows a diagram of the apparatus. The protons or other ions are liberated, by a suitable device, near the centre of a flat hollow cylinder which is divided into two parts separated from each other. The oscillating high frequency voltage is applied to these two parts and at the same time the whole cylinder is placed between the poles

of a powerful magnet. An ion starting at *a* is pulled by the momentary electric field across the gap and it takes, in the magnetic field, a circular path around to *b*. The frequency is adjusted so that by the time time it reaches *b* the direction of the voltage has reversed so that the ion is again speeded up as it crosses *b* back into the half-cylinder from which it started. Then by the time it reaches *c* the voltage has again reversed to its original direction and it is given another push, and so on and so on. The few-thousand-volts push is given to the ion every time it crosses the gap. It proceeds in ever-widening circles attaining a speed limited only by the dimensions of the apparatus. With this device, Lawrence and his colleagues have reason for hoping that the speeds may ultimately be increased up to perhaps the equivalent of ten million volts.

The currents are not very large, being reported of the order of a thousandth of a microampere. Nevertheless, these currents are tremendous in comparison with anything which can be obtained from radioactive material and this source of high-speed, electrified particles will evidently be an important tool in nuclear investigation, as is in fact evident from very recent reports from Professor Lawrence's laboratory in which the experiments of Cockcroft and Walton in disintegrating lithium nuclei by means of high speed protons have been confirmed and extended.

In the construction of this apparatus, the largest magnet ever built in this country has been put into use.

We come now to what I believe to be the most important development that has ever taken place in the field of extremely high voltages, namely the Van de Graaff generator, invented by Dr. Van de Graaff, as a result of considerations which were developed while he was a Rhodes scholar in England and which first took shape in the form of physical laboratory experiments at Princeton and which are now being developed and extended in the laboratories of the Massachusetts Institute of Technology.

From every point of view it is advantageous for very high voltages to have direct uniform currents. Van de Graaff was therefore led to develop an electrostatic generator, since electrostatic methods yield directly a steady uni-directional voltage such as is desired. Maximum simplicity was sought in the design. The simplest terminal assembly appeared to be a sphere mounted on an insulating column. Since the sphere must be charged and since the process should be continuous, the charge carrier should approach the sphere, enter it, and, after depositing its charge inside should return parallel to its path of ap-

proach. This immediately suggested the action of a belt, a device long used for the transmission of mechanical power.

The logic of the situation therefore pointed directly to a generator consisting of a hollow spherical conducting terminal supported on an insulating column, a moving belt to carry electric charge to the sphere, a device for depositing the charge onto the belt in a region of low potential remote from the sphere, and a device for removing this charge from the belt inside the sphere and transferring it to the sphere. A refinement of these essentials was the addition of an induction device whereby charge of the opposite sign was carried by the belt on its return journey, thus doubling the current output. A second refinement consisted of a self-exciting charging device whereby the entire generator could be made to operate independently of any external source of electricity. Not only does this device attain the desired result in what appears to be the simplest possible manner, but it is also interesting to note that the energy transformations in its operations are exceedingly simple, consisting only in the transformation of the energy required to drive the belt into work done in separating and transferring electric charge from earth potential to sphere potential. Fig. 5 shows, schematically, the operation of this generator.

By this means electricity is continually conveyed to the spherical terminal, whose potential consequently rises until limited by the breakdown of the insulation of the air in the form of a corona discharge at the surface of the spheres. This breakdown voltage depends on the size of the sphere, being approximately 750,000 volts for a 2-ft. sphere and increasing to 5,000,000 volts for a 15-ft. sphere. Thus the attainable voltage depends upon the size of the spherical terminal.

The current, on the other hand, is simply equal to the rate at which electricity is carried to and from the sphere by means of the belts, and this in turn depends upon the size, speed and number of belts and the quantity of electricity which can be placed on unit area of the belt. This latter quantity is also limited by the breakdown voltage of the surrounding air, to an amount of about 5×10^{-9} coulombs per sq. cm. of belt area. Under these conditions it is readily shown that a belt running at 6000 ft. per minute could theoretically carry a maximum current of 150 microamperes per inch width of belt. Actually, the best adjustments have given about half of this theoretical maximum, probably because the breakdown strength of the air is reduced by the mechanism whereby charge is sprayed onto the belts.

Theory and practice also show that these belts may be placed as close together as is geometrically possible, in fact, practically in

contact, without interfering with their capacity to carry charge. By packing many belts together it is therefore possible to produce very sizeable currents. For example, a small laboratory model for demonstration purposes, constructed this year in the laboratories at Massachusetts Institute of Technology, develops one and one-half million volts between a pair of 2-ft. spherical terminals, and delivers a current of 600 microamperes carried on two 8-inch belts in each sphere.

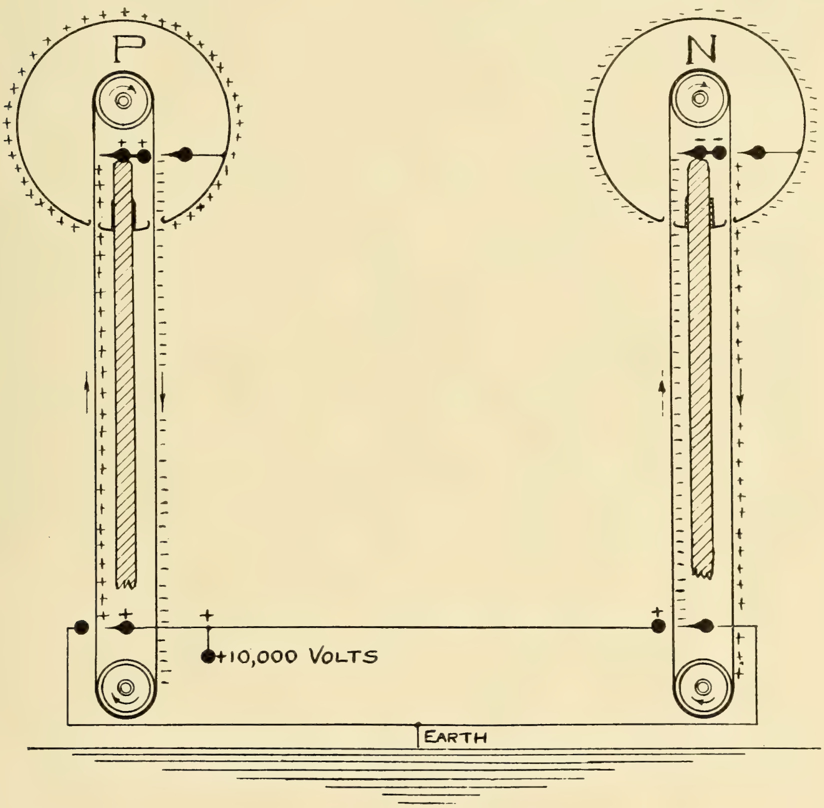


Figure 5.—Schematic diagram of Van de Graaff electrostatic generator.

Even in this small model the currents are approximately a million times greater than those which have been obtained in the high speed ion source designed by Lawrence.

The first model of such a generator which was actually constructed, was built in Princeton in the fall of 1929, being built out of a tin can, a silk ribbon, and a small motor, at no expense. This model developed 80,000 volts, being limited by the corona discharge from the edges of the can.

The next model was designed and built for operation in a vacuum tank for reasons to be outlined later.

The third model was built to give a quick and easy demonstration of the possibilities of the machine, using 2-ft. spherical terminals supported on pyrex rods, and supplied by current carried on silk belts $2\frac{1}{4}$ inches wide, driven by small motors. This apparatus was demonstrated successively in Princeton, New York, Washington, Boston, and elsewhere. Although built at a total cost of less than $100, it developed more than twice as high a voltage as any direct current generator of which we have knowledge.

Encouraged by the success of this model, plans were immediately made for the construction of as large a generator as seemed practical for operation in air, the limitation being placed by the size of the house in which it must operate. The largest place available was a dock built for a Goodyear dirigible on the estate of Colonel E. H. R. Green at South Dartmouth, Massachusetts, and which Colonel Green kindly put at the disposal of the Institute. Ten million volts was selected as the highest voltage which could be used in a building of this size without excessive loss of current through the air to the roof and walls. For this voltage, therefore, there has been built a generator with 15-ft. spherical terminals made of welded aluminum, mounted on 24-ft. textolite insulating columns in the form of 6-ft. cylinders, and carried on large fabricated steel trucks, running on a 14-ft. gauge railway track in order to vary the position of the terminals when desired.

In this construction the Research Corporation gave invaluable aid through assistance in the engineering drawings and through a grant of $10,000 which defrayed approximately half the cost of the generator.

Fig. 6 is a photograph of this generator, taken on the day before Christmas. In using this generator for experimental purposes it is planned to use the inside of the spheres as laboratory rooms, and to mount the discharge tube, suitably designed for producing high speed ions, between two spheres.

Every feature in the construction and operation of this large generator has gone as expected and a few days ago the first belt was put into operation and voltage generated as expected. This belt is made of paper 3 ft. wide and running at about 5000 ft. per minute. The initial trials gave an output of 600 microamperes, and previous experience indicates that with the proper adjustments this output may be increased to a milliampere. The design of the apparatus is

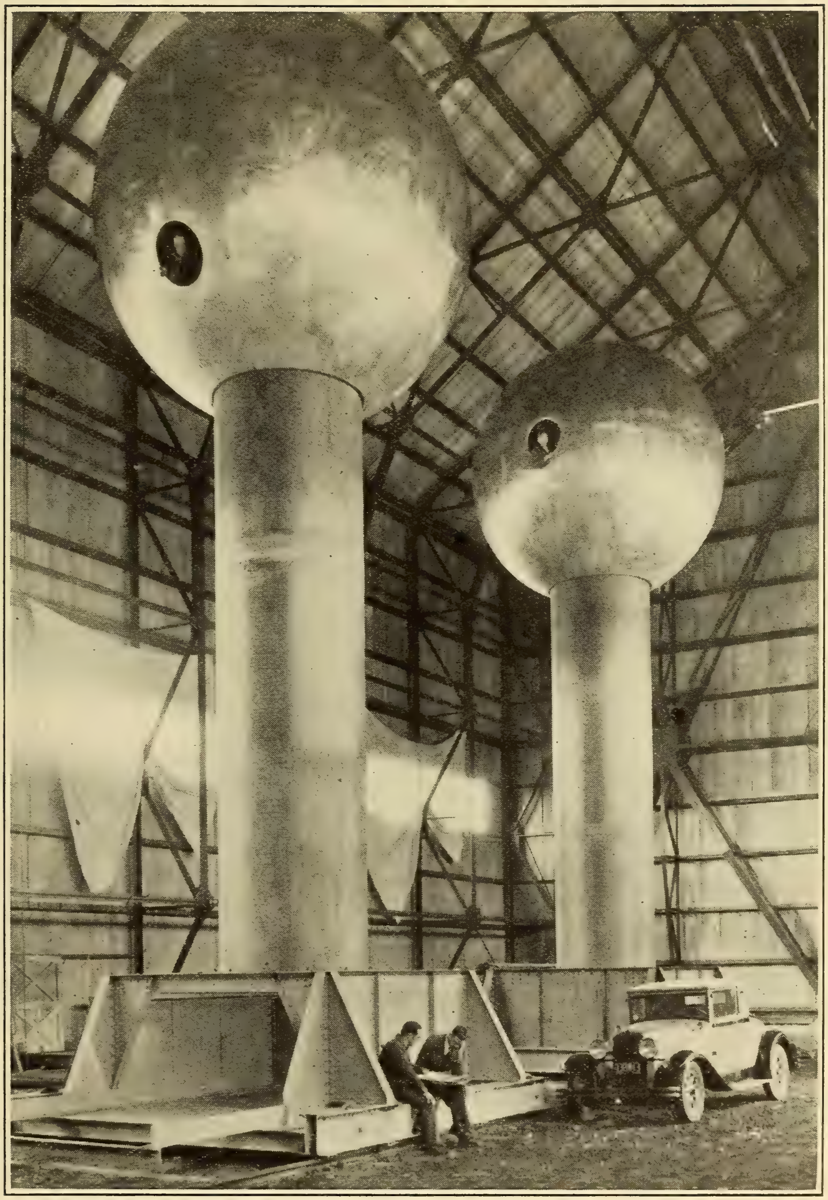


Figure 6.—The large Van de Graaff generator of the Massachusetts Institute of Technology.

such that a large number of belts may be made to operate in parallel, so that there will be no difficulty whatsoever in securing an output of between a tenth and a hundredth of an ampere if such large currents become desirable. It will be noted, however, that if currents as large as a tenth of an ampere are used at 10,000,000 volts, the generator will be delivering 1000 kilowatts!

The enormous possibilities of this machine become evident when we compare a possible input of 1000 kilowatts in the form of 10,000,000 volt electrified particles, with the sources which up to the present have been available for experiments on atomic disintegration and which have been principally small amounts of radioactive material.

We come now to a very interesting aspect of this type of generator, namely, the influence of the surrounding insulating medium. If the generator is placed in some medium whose electrical breakdown strength is greater than that of air, then the voltage and the current both increase proportionately and the power output increases as the square of the breakdown strength. The two media most convenient are either some gas such as air at high pressure, or a vacuum. With gas at high pressure, the breakdown strength is approximately proportional to the pressure, so that the operation of a generator in a tank of gas at 30 atmospheres pressure should give 30 times the voltage, 30 times the current and 900 times the power of the same device mounted in the open air. It is relatively easy to build a container for compressed gases and to mount a generator in it, and this, in fact, has been done by Doctor Barton at Princeton, originally with the collaboration of Doctor Van de Graaff.

By far the most intriguing possibilities of this generator are found in its vacuum embodiment, because a high vacuum is the best of all insulators since it offers no "windage" resistance to the motion of the belt, and since many of the applications of the high voltage will themselves be in vacuum discharge tubes which can be built right into the generating system.

Such a generator has been designed and built. It is still in the experimental stage but various complicating factors have one by one been overcome. Experience to date indicates that there is in sight no insurmountable obstacle to the construction of generators which may even reach considerably higher voltages than the generator at Round Hill.

In conclusion you will be interested to know, if you do not know this already, that two Van de Graaff generators have been built and operated in Washington under the direction of Dr. Merle A. Tuve

of the Department of Terrestrial Magnetism of the Carnegie Institution. One of these has been actually used for experiments on atomic disintegration and the other instrument, a larger one developing upwards of 2,000,000 volts, is awaiting a suitable housing now under construction, for its satisfactory operation. Dr. Tuve in Washington, Dr. Coolidge of the General Electric Company and Dr. Slack of the Westinghouse Company, all of whom have built and experimented with Van de Graaff generators subsequent to the demonstration of Van de Graaff's first air operated instrument in the summer of 1931, have been very helpful in reporting their experiences with the generators.

In conclusion it may fairly be said that this new type of generator as an electrical instrument, has already been highly successful and shows promise of very considerable further development. It remains to be seen whether the necessity which was the mother of this invention,—namely, the desire for high speed particles for the study of atomic nuclei,—will lead to important new knowledge of atomic structure with the aid of this device. Several good men are beginning work on the application of these voltages to nuclear disintegration, and it will not be long before some indications, at any rate, may be obtained as to the significance of the new developments in high voltage technique.

Whether or not the apparatus will be successful in opening up new fields of atomic investigation, it has already opened up the possibility for electrical investigations and possible practical applications of electricity in a new voltage range, and it will be surprising indeed if there are not some developments of scientific and practical significance which will eventually emerge from this new field of activity.

PHYSICS.—*Thin film lubrication of journal bearings.*[1] MAYO D. HERSEY, Research and Development Laboratories, Socony-Vacuum Corporation.

Some years ago[2] it was shown how the problems of lubrication might be simplified with the aid of dimensional reasoning. The treatment then given was restricted to thick film lubrication, assuming a uniform viscosity throughout the film, and assuming rigid or at least geometrically similar bearing surfaces, thereby excluding the

[1] Received April 27, 1933.
[2] This JOURNAL **4**: 542–552. 1914.

combination of a very heavy load with a very low speed. Even under those limitations the results were found practically useful, and in present day notation are usually referred to as the ZN/P relations.

This paper undertakes to extend the investigation to some of the simpler conditions of thin film lubrication.

THE CONCEPT OF THIN FILM LUBRICATION

Thin film lubrication has been described as a state in which the friction depends on some other property or properties in addition to the ordinary viscosity of the lubricant as measured at atmospheric pressure.[3] The term is not synonymous with boundary lubrication, where the effective properties of the lubricant are different from its bulk properties. Boundary lubrication may be considered a particular case of thin film lubrication. In general, thin film lubrication may be visualized as a state in which the bearing surfaces have been made to approach so closely that they can no longer be treated as perfectly smooth, perfectly rigid, and separated only by a perfectly adhering fluid of uniform viscosity.

A general study of thin film lubrication must therefore contemplate such phenomena as (1) velocity components, pressure gradients, and geometrical irregularities not recognized in Reynolds' equations; (2) localized pinching and heating effects between tangentially moving high spots on the opposite rubbing surfaces, resulting in non-uniform viscosity; (3) elastic deformation and thermal expansion, causing geometrical changes in the bearing surfaces; (4) boundary lubrication; (5) wear, seizure, and progressive chemical reactions, so far as they may properly be classed under the head of lubrication.

Kingsbury[4] found no departure from the ordinary laws of bulk viscosity down to films as thin as one forty-thousandth of an inch and up to rates of shear as high as 261,000 radians per second. Bulkley[5] found no evidence of plastic adsorbed films greater than one-millionth of an inch in thickness. Thus it appears that in practical journal bearings, we should expect the transition from thick film to thin film lubrication to be brought about due to the roughness of the surfaces, before there is any significant departure from bulk properties.

FACTORS AFFECTING THE COEFFICIENT OF FRICTION

With items (2) to (5) ruled out, the coefficient of friction, f, would

[3] Amer. Mach. **70**: 919, 921. 1929.
[4] Mech. Eng. **41**: 537. 1919.
[5] Bur. Standards Journ. Research (RP 264) **6**: 89–112. 1931.

be a function of the same variables entering into thick film lubrication. These variables are the absolute size of the bearing; its geometrical shape in every particular, including the clearance-diameter ratio, length-diameter ratio, and roughness; and the operating conditions, comprising the external load system, speed, and viscosity of lubricant. The load system may be specified by the load per unit of projected area together with the resultant couple, if any, taken about an axis perpendicular to the axis of rotation, such as might be caused by belt pull or misalignment. The viscosity of the lubricant may be specified by its value at atmospheric pressure and at the temperature of the bearing surface. It is assumed that the bearing is running in a practically steady state, with an unrestricted supply of homogeneous lubricant. For geometrically similar bearings the variables required by item (1) may therefore be catalogued as follows:

D, the journal diameter;
P, load per unit projected area;
M, moment of external couple;
N, speed in revolutions per unit time; and
Z, the viscosity of the lubricant.

The principal variables required by item (2) are the heat capacity per unit volume and thermal conductivity of the lubricant, together with its temperature and pressure coefficients of viscosity. The heat capacity determines the temperature rise in any particular volume element due to the heat generated by friction; the conductivity determines the temperature distribution; the temperature coefficient, in conjunction with other factors already mentioned, determines the decrease in viscosity due to local heating; and the pressure coefficient, with other factors, determines the increase in viscosity due to the relatively high local pressures that may be set up. To a first approximation it appears that the variables required by item (2) are:

a, the temperature coefficient of viscosity, or $(1/\mu)(d\mu/dt)$, in which μ is the viscosity at temperature t and pressure p;
b, the pressure coefficient of viscosity, or $(1/\mu)(d\mu/dp)$;
h, heat capacity of the lubricant per unit volume; and
k, conductivity of the lubricant.

Item (3) introduces phenomena governed by the elastic constants of the journal and bearing metals and their thermal expansivities. The elastic constants may be represented by Young's modulus and

Poisson's ratio. To a first approximation the latter may be considered constant, and the expansivities neglected because most of the expansion occurs between room temperature and the test temperature at which D, Z, etc., are measured. The principal variables called for by item (3) are therefore E_1 and E_2, Young's modulus for the journal and bearing respectively.

Although boundary lubrication, item (4), involves phenomena that are not yet understood, it would appear from the work of Hardy and others[6] that the coefficient of boundary friction may be assumed constant as a first approximation, provided (1) that the temperature variations are not too great, and (2) that sufficient time is allowed for the formation of the adsorbed layers. On this assumption the observed drop in friction with increasing speed under thin film conditions would be attributed to the coexistence of boundary lubrication with ordinary viscous action, the latter tending to separate the surfaces as the speed increases. For the purpose, then, of investigating thin film lubrication under conditions where boundary friction is a contributing but not the predominating factor, it may be tentatively assumed that the only additional variable called for by item (4) is the static coefficient, f_0.

Phenomena such as those described under item (5) which might permanently alter the identity of the bearing surfaces and of the lubricant, or involve appreciable expenditures of energy otherwise than in overcoming frictional resistance, are considered outside the scope of this investigation.

Collecting the variables listed above, it appears that the coefficient of friction under the conditions stated may be expressed by the qualitative relation

$$f = \text{funct}\ (D, P, M, N, Z, a, b, h, k, E_1, E_2, f_0); \qquad (1)$$

in which the requirement for geometrical similarity may be interpreted as applying only to the journal bearing in its unloaded state.

As there are still twelve independent variables left in spite of the severe narrowing down of the problem already undertaken, it is no great wonder that experimenters have found it difficult to obtain check results and to coordinate their observations in the field of thin film lubrication.

APPLICATION OF DIMENSIONAL THEORY

Four fundamental units are needed for measuring the thirteen quantities appearing in Eq. (1), as may be verified by inspection,

[6] Dictionary Appl. Physics, Macmillan, **1**: 572–579. 1922. Proc. Roy. Soc. A. **138**: 259–283. 1932.

since these involve thermal as well as kinetic quantities. Hence it follows from Buckingham's Π-theorem[7] that Eq. (1) is reducible to a relation connecting $13-4$, or 9 dimensionless products. One of the products may be identified with the coefficient of friction itself, so that Eq. (1) becomes

$$f=\phi(X_1, \ X_2, \cdots X_8), \tag{2}$$

in which ϕ is merely a symbol for some unknown function of the eight independent variables, or arguments, X_1, X_2, $\cdots X_8$.

The dimensions of the twelve quantities on the right of Eq. (1) are expressed in terms of force, length, time and temperature (F, L, T, θ) in Table 1, where colons have been used for convenience in place of the more conventional square brackets.

TABLE 1. DIMENSIONS ON THE F, L, T, θ SYSTEM

$D : L$	$Z : \frac{FT}{L^2}$	$k : \frac{F}{T\theta}$
$P : \frac{F}{L^2}$	$a : \frac{1}{\theta}$	$E_1 : \frac{F}{L^2}$
$M : FL$	$b : \frac{L^2}{F}$	$E_2 : \frac{F}{L^2}$
$N : \frac{1}{T}$	$h : \frac{F}{L^2\theta}$	$f_0 : 1$

One set of independent dimensionless products that may be constructed by reference to Table 1 is shown in Table 2. Other equivalent sets may be derived by interchanging quantities having the same dimensions. Eq. (2) may be expanded, if desired, by substituting directly into it from Table 2 or its equivalent.

This reduction in the number of independent variables from twelve to eight for thin film lubrication is less striking than the reduction from four to one obtained from the corresponding analysis of thick film lubrication.[8] Nevertheless, Eq. (2) in conjunction with Table 2 offers a definite guide for the planning and interpretation of experiments on thin film lubrication, an undertaking that would otherwise be even more complex than it now appears.

PROCEDURE FOR INCLUDING ADDITIONAL VARIABLES

If it is desired at any time to investigate the effect of additional quantities not included in Eq. (1) it will only be necessary to set up

[7] This JOURNAL **4**: 347. 1914. Trans. Amer. Soc. Mech. Eng. **37**: 263. 1915. Phil. Mag. **42**: 696. 1921.
[8] This JOURNAL **4**: 542–552. 1914.

TABLE 2. DIMENSIONLESS PRODUCTS FOR EQ. (2)

$X_1 = \frac{ZN}{P}$	$X_5 = \frac{k}{D^2PNa}$
$X_2 = \frac{M}{D^3P}$	$X_6 = \frac{E_1}{P}$
$X_3 = bP$	$X_7 = \frac{E_2}{E_1}$
$X_4 = \frac{h}{Pa}$	$X_8 = f_0$

by inspection the appropriate dimensionless product X corresponding to each new quantity introduced. Suppose, for example, any or all of the following quantities were to be included: (1) The latent period of Hardy, t_0, required for complete formation of the adsorbed layers under undisturbed conditions; (2) the density of the lubricant, ρ, as affecting its rate of escape from the space between tangentially approaching high spots, and its surface tension, S, as affecting its retention in the clearance space; (3) the second order coefficients of the viscosity-pressure-temperature surface, α, β, and γ, of which α denotes $\partial a/\partial t$, β denotes $\partial b/\partial p$, while γ denotes $\partial a/\partial p$ or its equal, $\partial b/\partial t$; (4) thermal expansivities, e_1, e_2, heat capacities, h_1, h_2, and conductivities, k_1, k_2, of the metals; (5) Poisson's ratio for the respective metals, σ_1, σ_2, and (6) the contact angles, A_1 and A_2, between

TABLE 3. ADDITIONAL DIMENSIONLESS PRODUCTS

Q	X	Q	X	Q	X
t_0	Nt_0	e_1	$\frac{e_1}{a}$	σ_1	σ_1
ρ	$\frac{\rho D^2N^2}{P}$	e_2	$\frac{e_2}{e_1}$	σ_2	σ_2
S	$\frac{S}{DP}$	h_1	$\frac{h_1}{h}$	A_1	A_1
α	$\frac{\alpha}{a^2}$	h_2	$\frac{h_2}{h_1}$	A_2	A_2
β	βP^2	k_1	$\frac{k_1}{k}$	....	....
γ	$\frac{\gamma P}{a}$	k_2	$\frac{k_2}{k_1}$	....	....

lubricant and metal. The new independent variable X corresponding to each new quantity Q is shown by Table 3. This procedure may be continued indefinitely.

While there is thus no difficulty in extending Eq. (2) to include as many variables as desired, it would seem to be of more immediate interest to examine the particular forms to which Eq. (2) may reduce when certain of the variables in Table 2 are held constant, or when the problem is sufficiently narrowed down to eliminate some of them.

DISCUSSION OF SPECIAL CASES

For properly loaded bearings $M=0$ so that X_2 of Table 2 disappears. Upon substituting into Eq. (2) we find for such bearings that

$$f=\phi_1\left(\frac{ZN}{P}, bP, \frac{H}{P}, \frac{K}{D^2PN}, \frac{E_1}{P}, \frac{E_2}{E_1}, f_0\right), \tag{3}$$

in which H has been written for h/a and K for k/a. That the three thermal properties a, h, and k should combine to form only two independent properties, H and K, is itself a noteworthy fact. It is also of interest that the absolute size, D, enters only one of the arguments of Eq. (3). This argument, X_5, appears to be a relatively unimportant one except for very low speeds; and if so, the equation assures us that the coefficient of friction will be relatively unaffected by changing the absolute size of the bearing, provided the corresponding bearing surfaces of different sizes are either practically smooth or similarly, not equally, rough. It is a familiar fact that the coefficient of friction is independent of size in thick film lubrication.

Limiting the analysis now to one particular bearing, $D=$const., $E_1=$const., and $E_2=$const.; so the argument X_7 disappears, while the remaining ones may be simplified. The factor P may as well be dropped from the first four arguments, since it now appears by itself in the fifth as an independent variable. Eq. (3) thus reduces to

$$f=\phi_2\left(ZN, P, b, H, \frac{K}{N}, f_0\right). \tag{4}$$

Eq. (4) is believed to be the most generally useful of any single equation in the paper. It suggests (1) that the viscosity of the lubricant, Z, can influence the coefficient of friction only through the product ZN; (2) that the conductivity of the lubricant affects the friction only through the ratio K/N; (3) that the results of experiments might be coordinated by plotting constant load curves ($P=$const.) with f

as ordinate against ZN as abscissa,[9] labelling each separate curve with the appropriate value of P, b, H, K/N, and f_0 so far as these can be determined.

The form of the variable K/N in Eq. (4) indicates that low conductivity has the same effect as high speed. This also is evident from any qualitative picture of the physics of thin film lubrication. If the lubricant were a perfect insulator, this variable would disappear, even at low speeds. In practice, the effect of K/N as well as the effect of f_0 may be expected to become negligible when the speed and viscosity are high enough. Eq. (4) then reduces to

$$f=\phi_3(ZN,\ P,\ b,\ H). \tag{5}$$

Under these conditions the pressure coefficient b and ratio of heat capacity per unit volume to the temperature coefficient of viscosity, H, would appear to be the two most significant properties of the lubricant, aside from its ordinary viscosity, Z.

APPLICATION OF HERTZ'S THEORY

For relatively smooth bearings where the general deformation, as distinguished from the deformation of the high spots alone, is considerable P may be replaced by P_0, the load per unit of effective contact area, or W/A_0 where W is the total load. Under these conditions X_6 and X_7 drop out since the effect of the elastic constants will be included in the factor A_0. From Hertz's theory[10] of cylinders in contact $A_0 \propto \sqrt{W}$, therefore $P_0 \propto \sqrt{W}$ and for one particular bearing, so that E_1, E_2, and D are constant, Eq. (3) may be written

$$f=\psi\left(\frac{ZN}{\sqrt{W}},\, b\sqrt{W},\, \frac{A}{\sqrt{W}},\, \frac{K}{n\sqrt{W}},\, f_0\right). \tag{6}$$

Possibly with smooth enough bearing surfaces, the effect of the arguments containing b, H, and K might be considered negligible to a first approximation. In this event Eq. (6) would reduce to the statement that for any one lubricant the coefficient of friction is a function of the single variable $ZN/\sqrt{W}$, a result that appears to be in accord with recent experimental data.[11]

FURTHER INVESTIGATION

In continuing this study it would seem desirable to consider (1) detailed calculation of possible magnitudes of the local pressures and

[9] For examples of charts in which f has been plotted against ZN see Zeit. V. d. I. **64**: 449. 1920. Proc. A. P. I., Sect. III, p. 154. 1932.

[10] HERTZ, H. Journ. f. Math. (Crelle) **92**. 1881. Ges. Werke, Leipzig, **1**: 155. 1895.

[11] McKEE, S. A. and McKEE, T. R. Journ. S. A. E. **31**: 371. 1932.

temperatures developed by the assumed tangential motion of rough spots; (2) tabulation of the pressure coefficient b and thermal constants H and K for available lubricants; (3) coordination of friction data in the light of the present results; (4) extension of the theory to gear lubrication; and (5) relation of thin film lubrication to the concept of oiliness.

PALEOBOTANY.—*The American white walnut or butternut,* Juglans cinerea *L., from the Upper Pliocene of Japan.*[1] SEIDO ENDO, Johns Hopkins University. (Communicated by E. W. BERRY.)

Description.—Nuts without outer soft part, ovoid-oblong in general outline, 4 to 6 cm. long, 2 to 3 cm. in maximum width and thickness, 4-ribbed, rough, deeply sculptured, and with about 4 sharp, longitudinal ridges, acuminated at apex, rounded at base; 2-celled at basal portion but 1-celled above in the inside, and about 4 mm. in thickness of the test.

Remarks.—The present materials are entirely identical in the outer ornamentation of the nut and inner features of the cell with the existing *Juglans cinerea* L., found in eastern North America. It now exists in New Brunswick and Ontario to North Dakota; south to Delaware; and in the Alleghanies to Georgia; and to Mississippi, Arkansas, and Kansas. It ascends to 2500 feet in Virginia.[2]

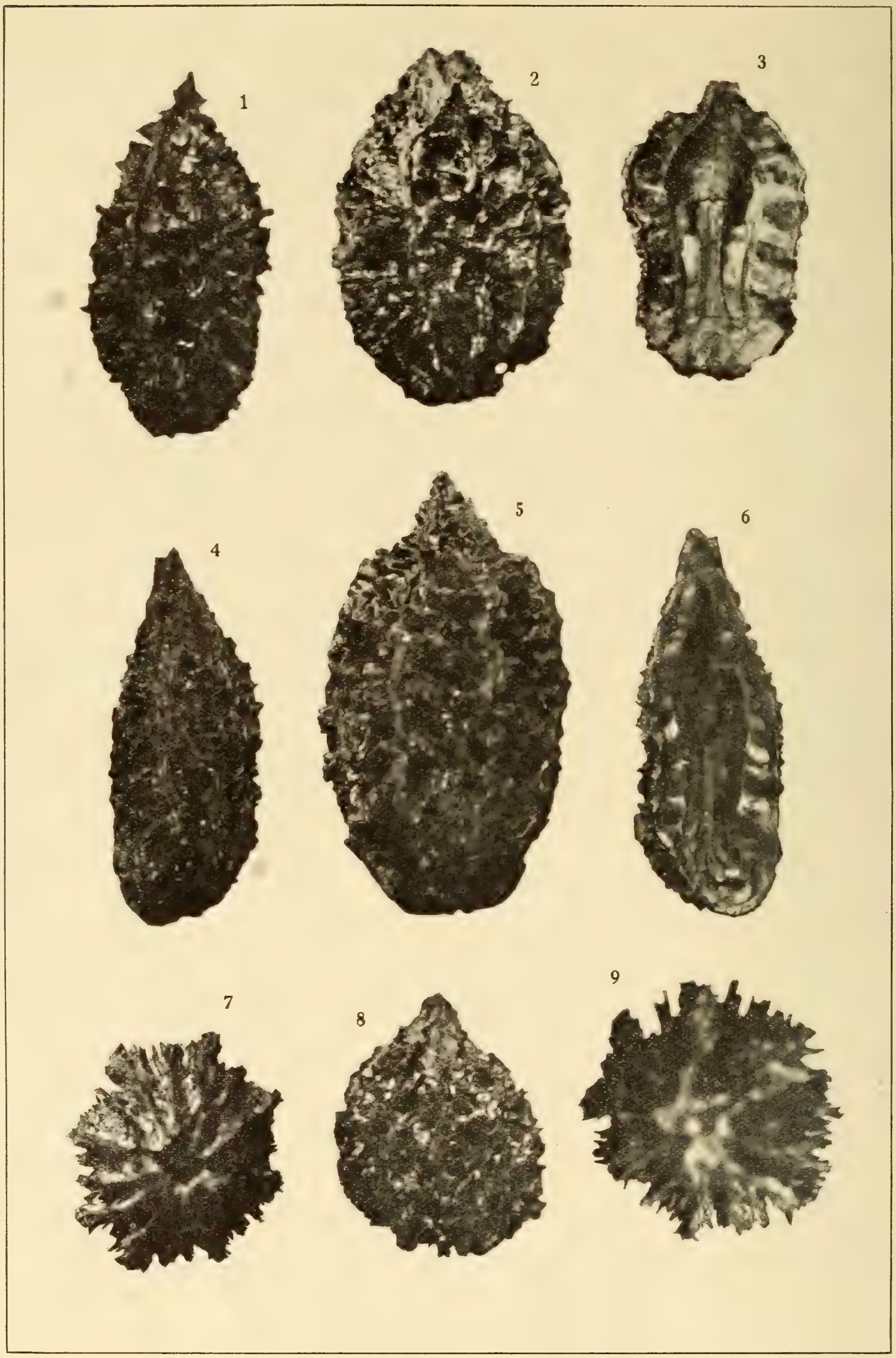
In the sizes of the fossil there are many variations. In this respect also it is closely allied to the existing species. Table 1 shows the comparison of the present materials and the existing species.

TABLE 1.—COMPARISON OF FOSSIL AND EXISTING SPECIES OF JUGLANS

NUMBER OF SPECIMEN	EXISTING SPECIES		FOSSIL MATERIALS	
	LENGTH	MAXIMUM WIDTH	LENGTH	MAXIMUM WIDTH
1	6.0 cm.	2.6 cm.	6.0 cm.	2.5 cm.
2	4.6	3.0	5.0	2.5
3	4.5	2.6	4.0	2.9
4	4.2	2.8	4.0	2.0
5	4.0	2.7	3.8	2.7
6	4.0	2.4	3.7	2.9

[1] Received January 24, 1933.

[2] BRITTON, N. L., and BOWEN, H. A. *An illustrated flora of the northern United States* 1: 579. 1913.



FIGS. 1–9. *Juglans cinerea* L.; 3, 6, The inner side; 7, 9, The basal portion. All slightly reduced.

These fossils were collected by F. Saito from Takagi, near Hanamaki-Machi, Iwate Prefecture, which is almost certainly Upper Pliocene in age, with many seeds (i.e. *Alnus*, *Prunus*, and *Styrax*, etc.).

Some years ago Hayasaka investigated other material from the same locality, without comparison with the existing material, and he described the species (in Japanese).[3]

Another occurrence from the Asiatic side is one on the River Aldan, which was described by Kryshtofovich.[4] This is quite similar to the present species and is almost certainly the same species.

From Europe this species was described by Engelhardt and Kinkelin from the Upper Pliocene of Klärbeckens and it is one of their most complete and beautiful specimens.[5] Ludwig described a species of *Juglans* (*J. gopperti* Ludwig) from the Pliocene lignite bed of Wetterau.[6] This is the nearest allied to our species. Another allied species is *Juglans tephrodes*, some of which[7] are quite similar to the present species.

Geological age.—As already stated, the present species was described by A. Kryshtofovich from eastern Siberia, a cleft of the Mammoth mountain on the left bank of the river Aldan, at a distance of about 45 versts from the mouth of the river Amga. He says:[8] "as to the age of the strata with *Juglans cinerea* L., if we follow Tschersky's conception, the appearance of these strata may be referred to the epoch of glacial phenomena in Europe, which is here indicated by the increasing moisture (and perhaps also by the softening of the climate?)."

This estimate of the age is somewhat doubtful because Tschersky's conception is also very doubtful.[9] With regard to another occurrence of *Juglans cinerea* from post-Pliocene of Europe[10] the writer has no

[3] Hayasaka, I. *On the fossil butternuts from Hanamaki-Machi, Iwate Prefecture, Japan.* Journ. Geogr. Tokyi **38**: No. 444. 1926 (Japanese).

[4] Kryshtofovich, A. *The butternut from fresh-water deposits of the Province of Yakoutsk.* Mem. du Comité Geologique, N. S. **124**: 25–32. *Figs.* 3*a*, *b*, *c*, *d;* 4*a*, *b*, *c;* 5*a*, *b*, *c;* 6*a*, *b*, *c;* 7*a*, *b*, *c;* 8*a*, *b*, *c*, *d.* 1915.

[5] Engelhardt, H. and Kinkelin, F. *Oberpliocane Flora und Fauna des Untermaintales, insbesondere des Frankfurter Klärbeckens.* Sencken. Naturfor. Gesell. Abhandl. **29**: 236. *pl.* 30, *figs.* 3, 4*a*, *b;* 5*a*, *b;* 6*a*, *b;* 7*a*, *b*. 1911.

[6] Ludwig, R. *Fossile Pflanzen aus der jüngsten Wetterauer Braunkohle.* Palaeont. **5**: 102. *pl.* 21, *figs.* 9, 9*a*, *b*, 10. 1857.

[7] Unger, F. *Sylloge plantarum fossilium,* I. Denk. Kais. Akad. Wiss., **19**: 38. *pl.* 19, *figs.* 12–15. 1860.

[8] Kryshtofovich, A. Op. cit. p. 31.

[9] Yabe, H. *On the climatic changes in Japan during the Pleistocene Epoch* (in Japanese). Reports Inst. Geol. and Pal., Tohoku Imp. Univ., Sendai, **3**: 1922.

[10] Kryshtofovich, A. Op. cit. p. 31; and Engelhardt, H., Kinkelin, F. Op. cit. p. 237.

accurate data[11] but in the deposits of Pliocene age there are many occurrences, as above mentioned.

It seems to the writer that the present species was widely distributed until upper Pliocene time, in the old world. It may, however, be almost absent from the deposits of Pleistocene age in most parts of the world except eastern North America.

The writer wishes to express his sincere thanks to Professor E. W. Berry for his valuable advice and assistance.

PALEOBOTANY.—*Fossil plants from Morrison, Colorado.*[1] EDWARD W. BERRY, Johns Hopkins University.

In the summer of 1916 the late Willis T. Lee collected a few very fragmentary fossil plants from the type section at Morrison, Colorado. These were the basis for a short paper[2] by the late Frank H. Knowlton published in March, 1920 in which these plants were compared with the Dakota sandstone flora and the following tentative identifications were listed:

Salix sp., cf. *Salix proteaefolia* Lesq.
Ficus daphnogenoides (Heer) Berry
Ficus magnoliaefolia Lesq. cf. *Eucalyptus dakotensis* Lesq.
Phyllites (2 species)

Preceding Knowlton's paper was one by Lee[3] advocating consideration of the Dakota as a group in this section, made up of the following 5 units:

1. Sandstone ("upper Dakota")
2. Sandy shale
3. Massive sandstone (Dakota of Lesquereux, "lower Dakota," Purgatoire)
4. Shaly sandstone (upper part of Morrison as originally described)
5. Conglomeratic sandstone ("Saurian conglomerate")

6, 7. Morrison formation
8, 9, 10. Sundance formation

This is sufficient, without a more extensive quotation, to render what follows intelligible.

The plants listed above on the authority of Knowlton came from member No. 4. I examined these after Knowlton's death and labelled them undeterminable. More recently I have looked them over again

[11] The occurrences of *Juglans cinerea* L. of Pleistocene age in Europe are very doubtful both as to the determinations and the geological age of the localities.

[1] Published with the permission of the Director of the U. S. Geological Survey. Received February 24, 1933.

[2] KNOWLTON, F. H. Amer. Jour. Sci. **49**: 189–194. 1920.

[3] LEE, W. T. Amer. Jour. Sci. **49**: 183–188. 1920.

more carefully. The collection consists of 16 pieces of a grayish gritty matrix with fragmentary carbonaceous impressions. The Survey Locality number is 7225 (Lee's No. 1262). Knowlton did not label any of the specimens but for most of them it is possible to pick out the ones to which the above names were meant to apply.

It will be noticed that but one of these was positively named. This was *Ficus magnoliaefolia*. The type of this species was described by Lesquereux[4] in 1883 from collections made by Lieutenant Beckwith at Morrison which, according to George L. Cannon as quoted by Lee, came from No. 3 of the section quoted above. Subsequently Lesquereux identified this species[5] from Ellsworth County, Kansas. These two are similar but not identical, although I am not prepared to say that they could not represent the same species. The single specimen in the Lee collection has an outline more like the Kansas leaf than it is like the type, but again there are slight differences especially in the fewer secondaries in the Lee specimen. The material is too poor for a positive determination and I would certainly hesitate to vouch for its correctness. The other species supposed to be represented are still more vague and fragmentary and I do not regard any of them as entitled to any weight in arriving at the age of the horizon.

Accompanying the collection from Loc. 7225 are 5 specimens in a brownish gritty sandstone with brownish impressions of fragmentary leaves collected by Lee from a horizon 25 ft. above the base of No. 3 (Purgatoire). These bear the Survey Locality No. 7224 (Lee's No. 1267). None of these are accompanied by identifications and I certainly regard them as undeterminable, although they have a Dakota aspect.

A single additional specimen bearing Locality No. 7225 is a loose piece sent in by Lee. The covering note states "It seems to come from the Morrison but might easily be the Dakota." The lithology and character of the leaf impressions are that of Loc. 7224 and not that of 7225.

One face has a perfectly recognizable leaf of *Aralia wellingtoniana* Lesq. and the other face the greater part of a lanceolate leaf of *Ficus daphnogenoides* (Heer) Berry. The first is a Dakota, Raritan, Woodbine species and the second occurs in all of these formations and in the Magothy and Tuscaloosa in addition.

In the summer of 1921 Dr. Stanton visited the Morrison region and made a collection of plants from a shaly lens near the middle of No. 3

[4] LESQUEREUX, L. Cret. and Tert. Fl., p. 47. *Pl.* 17, *figs.* 5, 6. 1883.
[5] LESQUEREUX, L. Dakota Flora, p. 79. *Pl.* 16, *fig.* 4. 1892.

of Lee's section (quoted above). The exact locality is north of Bear Creek at Morrison on the west slope of the Dakota hogback and the specimens bear the Survey Locality No. 7501 (Stanton's No. 1892). Dr. Stanton informs me that this shaly lens is about 50 feet above a plant-bearing bed which in his opinion is the horizon from which came Lee's collection, that is, "4. Shaly sandstone (upper part of Morrison as originally described)" and the basis of Knowlton's published paper. The Stanton collection is also of very scrappy material but it contains one specimen that can be positively determined and which

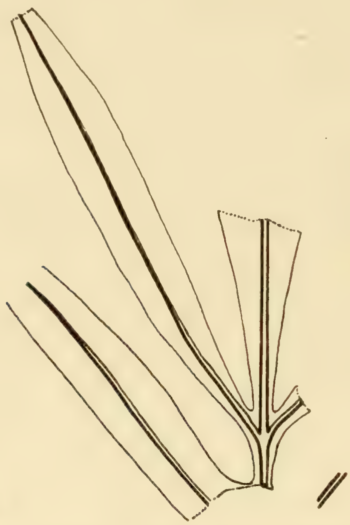


Fig. 1. *Sapindopsis* from Morrison, Colorado.

is figured herewith and undoubtedly is *Sapindopsis variabilis* Fontaine.

The genus *Sapindopsis* was proposed by Fontaine[6] in 1890. Some years later the writer[7] redefined it and pointed out its nearest living relatives among American genera of the Sapindaceae. Three species were recognized and these came from the Patapsco formation of Maryland and Virginia, and there is satisfactory evidence for assigning the Patapsco formation to the Albian stage of the European time scale, i.e. near the top of the Lower Cretaceous.

In more recent years one or the other of the three original species have been found in a number of other regions, all North American

[6] Fontaine, W. M. Mon. U. S. Geol. Survey **15**: 296. 1890.
[7] Berry, E. W. Md. Geol. Survey, Lower Cretaceous, p. 467. 1911.

however, and a fourth and better characterized species has been added from the Cheyenne sandstone of southern Kansas.[8]

The Patapsco species *Sapindopsis variabilis* was the most common species in that formation, and as its name indicates, it shows considerable variability and appears to grade into what was called *Sapindopsis magnifolia.* In all these species the thick lanceolate detached leaflets are easily confused with the lanceolate leaves or leaflets of other and unrelated genera and at one time or another one or the other have been referred to *Eucalyptus, Ficus, Aralia,* and *Rhus.* This is particularly true where the specimens are entombed in sandstones and were more or less macerated before burial, as in the so-called Fuson formation of the Black Hills. The present specimen is unmistakably a part of a leaf of *Sapindopsis variabilis* showing parts of five rather narrow leaflets and is particularly good and characteristic of the three distal leaflets. These are rather narrower than usual but not narrower than many I have seen. Their coalescent bases and winged rachis are unmistakable, and could not possibly be confused with any other Cretaceous plant. They show no venation other than midveins, and failure to note that they were leaflets and not lanceolate leaves would readily lead one to compare them with *Salix* or *Eucalyptus.* Both what has been called *Salix proteaefolia* as conceived by Lesquereux and not by Newberry, and *Eucalyptus dakotensis,* both tentatively identified by Knowlton from No. 4 of the section at Morrison, might be and probably are only the leaflets of *Sapindopsis variabilis.* This indicates that the two plant-bearing beds at Morrison—one in No. 3 of Lee's section and the other in the upper part of No. 4 of the same section—contain essentially the same flora and presumably belong to the same formation.

Sapindus variabilis is exceedingly common at many localities in the Patapsco formation of Maryland and Virginia and is by far the most characteristic species of that formation. It was identified by Ward from the supposed Fuson formation of the Black Hills at Oak Creek, Wyoming, and is common in the Cheyenne sandstone near Belvidere, Kansas. Cockerell[9] suggested this species for some undetermined material from an unknown geologic horizon in southwestern Colorado, photographs of which material I have examined and consider very inconclusive.

The certain presence of *Sapindopsis* in the section at Morrison casts considerable additional doubt upon Lee and Knowlton's as-

[8] Berry, E. W. U. S. Geol. Survey Prof. Paper **129**: 216. *Pls.* 49–54. 1922.
[9] Cockerell, T. D. A. This Journal **63**: 110. 1916.

signment of one of the plant-bearing beds to the Morrison formation, but the question as to whether the age is late Lower or early Upper Cretaceous remains as uncertain as before, and is complicated by the fact that the so-called Dakota flora of the Denver Basin came from beds now referred to the Purgatoire formation and not from what I would call the true Dakota in the restricted sense as the littoral deposits of the Benton sea and the synchronous continental deposits of the time represented by that transgression.

It is probably true that what has been called Purgatoire is to be correlated with the Mentor formation and Cheyenne sandstone of Kansas, but so far as the range of *Sapindopsis* is evidence its horizon could equally fit into the top of the Lower or the base of the Upper Cretaceous. It certainly does not seem to me to afford any direct evidence regarding the age of the Dinosaur-bearing Morrison, although I would be inclined to regard it as circumstantial evidence of the Lower Cretaceous rather than the Jurassic age of the Dinosaur-bearing Morrison.

ZOOLOGY.—*Notes on shrimps of the genus* Macrobrachium *found in the United States.*[1] WALDO L. SCHMITT, U. S. National Museum.

From time to time specimens of the larger freshwater shrimps of the genus *Macrobrachium* have been received at the United States National Museum for identification. Information yielded by some of these sendings is of such interest that publication seems desirable.

Macrobrachium acanthurus (Wiegmann), though long known to range from the Rio Grande River in Texas to Rio Grande do Sul, Brazil; Panama, and Ecuador,[2] is here for the first time recorded east of Texas. On January 11, 1922, a specimen was taken, it was said, from "brackish water" near Lockport, Louisiana, and sent to the United States Bureau of Fisheries by Mr. E. A. Tulian, then Superintendent of the Fisheries Division of the Louisiana Department of Conservation. Not only did this specimen extend the range of the species eastward across the whole of the state of Texas, but it also proved to be the largest *M. acanthurus* ever seen at the Museum. The specimen measures from the tip of the rostrum to the extremity of the telson all of 170 mm.; the large chela is about 74 mm. long.

This species must be of comparatively rare occurrence in the state, for when asked about the matter, Mr. Tulian replied that "so far

[1] Received February 15, 1933.

[2] RATHBUN, M. J. Proc. U. S. Nat. Mus. **38**: 604. 1910. We also have specimens in the National Museum extending the range of *M. acanthurus* northward along the west coast of North America to Mazatlan, Mexico.

as we are aware, only four of such shrimp have been taken from our waters." No further specimens have ever come to the attention of the Museum, though the State fisheries representatives were, at that time instructed to be on the watch for them. Five years later, August 29 1927, the first *M. acanthurus* was found in Mississippi, at Ocean Springs, where Captain Ellis Handy captured two specimens in a partly sunken boat. One of these was forwarded to the National Museum for determination, through the interest of Dr. R. W. Harned, then of the State Plant Board of Mississippi. Captain Handy never before had encountered this form, nor has it since come to our notice from this state. In a quite recent check-up, I wrote Captain Handy. He replied, "The specimen sent in was discovered by accident as a sunken barge was raised in Fort Bayou. As the water was bailed out I found two small and one large shrimp and the peculiarity of it made me send the larger one in for identification. At the time no local man could tell me anything of it. I have made the rounds of the local fishermen, particularly those who use troll boats and seines. Three or four men stated that they had almost every season found two or three similar shrimp in their catch."

The very next year, however, we were apprised of the presence of *M. acanthurus* in Florida. In August, 1928, Mr. Robert Ranson, of St. Augustine, shipped us two lots, thirty-seven specimens in all, that had been taken from the large central pool of the patio of the Alcazar Hotel, a very considerable eastward extension of the range of the species.

No less remarkable is the fact that in company with these specimens from Florida were found a *Macrobrachium jamaicense* (Herbst), and two specimens of *M. olfersii* (Wiegmann). With these were three other incomplete specimens; one has been tentatively referred to *M. jamaicense*, and the other two to *M. olfersii.*

Naturally, the question was raised as to how these shrimp could have gotten into this enclosed pool. At first it was suspected that they might have been unwittingly introduced with the tropical fish with which the pool had been stocked. Mr. Ranson looked into this phase of the matter, and a month later wrote that the *Macrobrachium* had been noted for some years in these pools, but the sword-tails had been introduced only the previous year from South America. He was convinced that the shrimps had entered the pool by means of the overflow drain leading to a stream outside. If there are any doubts regarding the streams outside as the source of the *M. acanthurus* found in the Alcazar pool, it would seem that additional records of the

occurrence of the species in Florida would set them at rest. Two such finds did come to us less than two years later. In the summer of 1930 Captain John Mills, of the yacht "Anton Dohrn" of the Tortugas Marine Laboratory of the Carnegie Institution, gave me two specimens from the Miami River, which had been caught under a set of ways on which one of the laboratory launches had been hauled out for repairs. He tells me (Sept., 1932) that there used to be quite a lot of them in the river, and that as soon as the present dredging operations which have made the water too muddy to look for shrimp have been completed, he will get me additional specimens. The same year, Mr. Edward J. Brown, sent us a specimen from Coconut Grove, Florida.

Macrobrachium jamaicense (Herbst) has perhaps a wider range than the preceding form, having heretofore been found in the "fresh waters of the Pacific slope of North America from Lower California to Peru, and the Atlantic slope, from Texas to Brazil, including the West Indies."[3] Now, by means of Mr. Ranson's Alcazar pool collections, we are enabled to establish a first record within the continental United States other than from the state of Texas, and a second from Silver Springs, Marion County, in the same state, where Mr. E. Ross Allen has speared several from as much as thirty feet or more of water. Two of these Silver Springs specimens have come into the possession of the National Museum through the kind offices of Dr. T. Van Hyning of the Florida State Museum at Gainesville. Though the larger is of good size, measuring from tip of rostrum to the extremity of the telson 202 mm., with a larger chela of about 92 mm., Dr. Van Hyning wrote at the time that "we still have one other specimen about twice the size of the present one, and in some ways in better condition, which we are saving for the exhibition series."

Mr. Allen told me that the largest specimen he ever took in Silver Springs was twenty-two inches (nearly 559 mm.) long, measured from the end of the telson to the extremity of anteriorly extended claws. This exceeds by about two inches the largest specimen in the National collections which was taken in Devil's River, Texas, by Mr. John Roth, the donor, in 1910. Weighing three pounds, it measures from tip of rostrum to extremity of telson a shade over 266 mm.; larger right chela, movable finger, and palm taken together, 188 mm. Following a personal visit to Washington this past summer, Mr. Allen kindly donated to the National Museum a very large specimen, but yet intermediate in size between the two just mentioned, together with two chelipeds of another specimen or two. The larger of these legs has

[3] Rathbun, M. J. loc. cit.

a chela or claw about seven and five-eighths inches (about 193 mm.) in length and also a little larger than the larger cheliped of our Devils River specimen.

Macrobrachium olfersii (Wiegmann) has been found to range from La Paz, Lower California, to the Rio Sabana, Panama, and from Vera Cruz, Mexico, to Rio de Janeiro, Brazil, including also the West Indies.[4] A rather unexpected record for the continental United States is the one established by Mr. Ranson (mentioned above) for the Alcazar Hotel pool, St. Augustine, Florida. These particular specimens are of fair size, 78 and 81 mm. long, with larger chela of each about 43 mm. long and about 12 and 13 mm. wide respectively. The largest of this species in the National Museum, by the way, was received over thirty years ago. It comes from La Situ, Guadeloupe, and from tip of rostrum to extremity of telson measures 90 mm. long, large chela about 50 mm. long by 14 mm. wide, exclusive of spines.

Macrobrachium ohionis (Smith), according to the last published statement regarding its distribution, "is found in the Mississippi and lower Ohio Rivers (up to Cannelton, Ind.)"[5] The specimens of this species preserved at Washington are mostly from the state of Louisiana, and these chiefly from the lower Mississippi in the general vicinity of New Orleans and Lake Pontchartrain; with several from Lake Lapourde, Morgan City, and Calcasieu Pass. Texas is represented by a number of specimens from the Trinity and Lavaca Rivers, and a few from Big White Oak Bayou, two miles south of Houston. On the other hand, we possess but a single record from the state of Mississippi, a lone individual from Baldwin Lodge, near the Gulf Coast, and not far from the Louisiana-Mississippi state line; perhaps to be considered as being in the general region of New Orleans.

It was, therefore, of considerable interest that two shrimp sent in for determination from Savannah, Georgia, in 1929, by Mr. Ivan R. Tomkins, of the U. S. Dredge "Morgan," should prove to be *M. ohionis*. They were found just above the city of Savannah in fresh water. In May, 1930, he sent two more specimens of *M. ohionis*, both ovigerous, from the entrance of the Altamaha River, Georgia; and just this last June he sent more specimens that were found together at the foot of East Broad Street (Savannah) in 2-10 feet of water with the notation that "the water was quite fresh at that stage of the tide."

It was even more surprising to learn, in checking over the Museum's

[4] Rathbun, M. J. loc. cit.
[5] Ortmann, A. E. in Ward and Whipple, Freshwater Biology, p. 845. 1918.

files, that a good many years ago another specimen of this very species from our southeastern coast had been identified, but never published, by Dr. Mary J. Rathbun. This happens to be the largest specimen of the species in our collection, and perhaps the largest known. It was collected by Mr. J. W. Milner in 1878 at Avoca, North Carolina. From the tip of the rostrum to the extremity of the telson it is just about 102 mm. long. The chelae are lacking from the large, second, pair of legs.

Were it not for this early find of Mr. Milner's, one would have been tempted to believe that these usually more tropical Mexican and Central and South American shrimps, and our own *Macrobrachium ohionis* of the Mississippi water-shed and westward were gradually making their way eastward along the Gulf coast, and northward along the east coast of the United States.

From what has been here brought together, it would seem that at least the larger bodies of fresh water of our southern, and central states, especially rivers which might harbor the larger shrimps, *Macrobrachium*, have received altogether too little attention from biologists. For example, Forbes, back in 1876, recorded[6] "*Palaemon ohionis* Smith abundant at Cairo, where it is frequently eaten. Smaller specimens were taken in the Mississippi near Grand Tower, in Jackson county, and it is reported by boatmen to occur from St. Louis to New Orleans, growing larger towards the south. It has not yet been found in the Illinois River."

Is *M. ohionis* confined to the Mississippi below St. Louis and the lower Ohio to the exclusion of the other larger tributaries of these rivers? Whether or not, certainly an interesting ecological and distributional problem is here awaiting study; likewise, with the other North American species of *Macrobrachium*.

Except for friends of the Museum and certain amateur naturalists much interested in the world about them, these extensions of range would have gone undiscovered. Further observations or notes on these and any other fresh water shrimps found in the United States as well as specimens will be greatly appreciated.

While this note was yet in proof I received from Captain Mills another large freshwater shrimp which he caught in a boat slip at Fogel's shipyard close by the railway bridge crossing the Miami River, in Miami, May 17, 1933. It is an old *M. jamaicense,* 236 mm. long from end of telson to the tip of rostrum, which appears not to have moulted for some time as it is much overgrown with serpulid tubes. The larger left chela, fingers and palm to-

[6] FORBES. *List of Illinois Crustacea.* Ill. Mus. Nat. Hist. Bull. 1: 5. 1876.

gether, is approximately 200 mm. long. Compared with the exceptionally large Silver Springs specimen above, it is about 5-3/4 inches shorter, measured as Mr. Allen did his, from the hinder margin of the telson to the ends of the fingers of the extended chelipeds.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

251st MEETING

The 251st meeting of the Academy was held in the Auditorium of the Interior Department Building on Thursday, January 12, 1933. About 240 persons were present. Doctor Marius Barbeau, Ethnologist, National Museum of Canada, delivered an address illustrated with motion pictures and lantern slides on *French Canada: its survival.*

At the close of the address the President declared a recess for a few minutes.

The 35th annual meeting of the Academy was called to order at 9:45 by President Adams; 31 members were present.

The report of the Corresponding Secretary, Paul E. Howe, showed the following items of general interest:

Membership: During the year 1932, 29 persons were elected to regular membership. Of those elected, 27 had accepted and qualified for membership before the end of the year and 2 had declined membership. Doctor Charles E. Munroe, Forest Glen, Maryland, was elected to honorary membership in recognition of his eminence as a chemist, educator, and explosives engineer. Thirty-one resignations were accepted, of which twelve were resident and 19 non-resident members. The Academy lost by death 22. The net loss in membership was therefore 26 or 4.6 per cent.

By request of the President the Academy stood while the Secretary read the following list of deaths reported during the year:

Louis W. Austin	C. F. Langworthy
S. I. Bailey	C. Dwight Marsh
Outram Bangs	William J. Holland
Louis A. Bauer	Ernest Howe
A. C. Gill	W. B. Parsons
George K. Burgess	Irwin G. Priest
N. A. Cobb	C. W. Richmond
G. L. Coyle	W. A. Slater
B. K. Emerson	F. W. Stevens
B. W. Evermann	W. S. Thayer
R. L. Faris	C. P. Townsend

On January 1, 1933, the membership consisted of 15 honorary members, 3 patrons, and 543 members, one of whom was a life member. The total membership was 561 members, of whom 388 reside in or near the District of Columbia, 147 in other parts of the continental United States, and 26 in foreign countries.

The Recording Secretary reported that the 35th year of the Academy began with the 246th meeting and ended with the 251st meeting. Two of the six meetings were joint meetings—the 249th with the Geological Society and the 250th with the Philosophical Society. The minutes of these meetings are published in the Journal.

The Treasurer reported that the receipts of the ACADEMY during the past year amounted to $7457.29 including return of investments of $2050.00 and interest on investments of $1293.03. The disbursements amounted to $7749.14 including an investment of $2062.50. The bank balance at the end of the year was $1576.84. The investments of the ACADEMY comprise $6337.50 in stocks, $6808.87 in bonds and $8000.00 in real estate notes making a total of $21,146.37 computed on the basis of cost to the ACADEMY. The assets of the ACADEMY were estimated as $22,913.03.

The report of the Auditors approving the Treasurer's accounts was received and filed.

Upon motion of Doctor GRIGGS, thanks of the ACADEMY were extended to the Treasurer for the wisdom with which he had protected the investments of the ACADEMY.

The report of the Board of Editors was presented by the Senior Editor, HUGH L. DRYDEN. The report stated that volume 22 consisted of 572 pages and 79 original papers and was illustrated by 23 halftones and 61 line cuts. The total cost per page, exclusive of reprints, was $6.62. The cost to the ACADEMY of supplying 50 free reprints was approximately $0.60 per page. The report described the changes of policy authorized by the Board of Managers as a result of the work of the special Journal Committee, namely, the change to monthly publication, the contract with Science Service to provide news notes, the new printing contract, and the attempt to provide one article of general interest in each issue. Upon motion of L. B. TUCKERMAN, a vote of thanks was extended to the Board of Editors for the efficient handling of the Journal during the past year.

Doctor L. A. ROGERS, Chairman of the Board of Tellers, reported 164 ballots counted with the election of the following officers: *President*, ROBERT F. GRIGGS; *Non-resident Vice-Presidents*, F. A. VENING-MEINESZ and EDWARD A. BIRGE; *Corresponding Secretary*, PAUL E. HOWE; *Recording Secretary*, CHARLES THOM; *Treasurer*, H. G. AVERS; *Managers for the term of three years ending January, 1936*, M. C. HALL and S. A. ROHWER.

The list of Vice-Presidents nominated by affiliated societies was read by the Recording Secretary as follows:

Anthropological Society,	N. M. JUDD
Archaeological Society,	J. TOWNSEND RUSSELL
Bacteriological Society,	N. R. SMITH
Biological Society,	H. H. T. JACKSON
Botanical Society,	C. L. SHEAR
Chemical Society,	E. WICHERS
Columbia Historical Society,	ALLEN C. CLARK
Electrical Society,	E. C. CRITTENDEN
Entomological Society,	HAROLD MORRISON
Geological Society,	F. E. MATTHES
Helminthological Society,	G. STEINER
Medical Society,	H. C. MACATEE
National Geographic,	F. V. COVILLE
Mechanical Engineers,	O. P. HOOD
Military Engineers,	C. H. BIRDSEYE
Philosophical Society,	H. L. CURTIS
Society of Foresters,	F. C. CRAIGHEAD
Washington Engineers,	N. H. HECK

By vote of the ACADEMY the Secretary was directed to cast one ballot for the list as read and the Vice-Presidents were declared elected. The Chairman of the Board of Tellers, L. A. ROGERS, reported the approval of the affiliation of the Washington Section of the Institute of Radio Engineers.

The senior Vice-President, H. L. CURTIS was appointed to escort President ROBERT F. GRIGGS to the chair. The new President addressed the Academy briefly. He appointed H. L. DRYDEN, senior editor, and Vice-President STEINER as members of the executive committee, and JOHN A. STEVENSON to the Board of Editors. He declared the meeting adjourned at 10:23.

252ND MEETING

The 252d meeting of the ACADEMY was held in the Assembly Hall of the Cosmos Club on Thursday, February 16, 1933. About 125 persons were present. President R. F. GRIGGS introduced Doctor L. H. ADAMS, retiring President of the ACADEMY, who delivered an address on *The basic concept of the physical sciences.*

CHARLES THOM, *Recording Secretary.*

ANTHROPOLOGICAL SOCIETY

The Anthropological Society of Washington at its annual meeting held on January 17, 1933, elected the following officers for the ensuing year: *President,* J. N. B. HEWITT; *Vice-president,* MATTHEW W. STIRLING; *Secretary,* FRANK H. H. ROBERTS JR.; *Treasurer,* HENRY B. COLLINS JR.; *Vice-President of the Washington Academy of Sciences,* N. M. JUDD; *Members of the Board of Managers,* BIREN BONNERJEA, GEORGE S. DUNCAN, HERBERT W. KRIEGER, FRANK M. SETZLER, WILLIAM DUNCAN STRONG.

The following is a report of the membership and activities of the Society since the annual meeting held on January 19, 1932.

Membership:	
Life members	3
Active members	52
Associate members	6
Honorary members	22
Corresponding members	22
Total	105
Deceased:	
Active members	2
Life members	1
Honorary members	1
Total	4
Resigned:	
Active members	4
Associate members	1
New Members:	
Active	3
Transferred:	
Active to Associate	1

The Society lost through death the following members: Dr. DANIEL FOLKMAR, past secretary, July 21, 1932; and Dr. FRANCIS LAFLESCHE, past president, September 5, 1932; active members. Baron ERLAND NORDENSKIÖLD, July 1932, honorary member. Mrs. F. WILSON POPENOE, December 30, 1932, life member.

Members resigning at the close of the year were: H. S. Bernton, W. H. Jackson, Henry C. MacAtee, and R. H. Reichelderfer, from the active list; and F. Wilson Popenoe from the associate group.

Members elected during the year were: Erik K. Reed, Frank M. Setzler, and Loren L. Wedlock.

Mr. Marcus Goldstein transferred his membership from active to associate.

The financial statement (Treasurer's report) is as follows:

Funds invested in Perpetual Building Association	$1034.15
21 Shares Washington Sanitary Improvement Co., par value $10 per share	210.00
2 Shares Washington Sanitary Housing Co., par value $100 per share	200.00
Cash in bank	201.84
Total	$1645.99
Bills outstanding	None

Papers presented before regular meetings of the Society were as follows:

January 19, 1932. 636th regular meeting. *The Indians of the Northern Plains*, by Dr. Robert H. Lowie, professor in anthropology, University of California.

February 25, 1932. 637th regular meeting. *The archeology of the Southwest, from the basket makers to the pueblos*, by N. M. Judd, curator of archeology, U. S. National Museum. *The ethnology of the pueblo peoples in contrast to the other peoples of the Southwest*, by Dr. Wm. Duncan Strong, ethnologist, Bureau of American Ethnology. By vote of the Board of Managers this meeting was changed from the regular date, February 23 to the 25th.

March 15, 1932. 638th regular meeting. *Recent excavations in France and Czechoslovakia*, by J. Townsend Russell Jr., honorary collaborator in Old World Archeology, U. S. National Museum.

April 19, 1932. 639th regular meeting. *World history as a cultural tug of war*, by Dr. John M. Cooper, Catholic University of America. This was the retiring presidential address.

October 18, 1932. 640th regular meeting. *The Jivaro Indians of eastern Ecuador*, by Matthew W. Stirling, chief, Bureau of American Ethnology.

November 15, 1932. 641st regular meeting. *In the Brazilian wilderness, an account of the Matto Grosso expedition to Brazil*, by Vincenzo M. Petrullo, University of Pennsylvania Museum.

December 20, 1932. 642d regular meeting. *Bush Negroes and Choco Indians of northwest Colombia*, by W. A. Archer.

Papers presented before special meetings of the Society were as follows:

January 5, 1932. *Indians of the Great Basin*, by Dr. Robert H. Lowie, professor in anthropology, University of California.

February 11, 1932. *The Indians of California*, by Dr. A. L. Kroeber, professor in anthropology, University of California.

A special joint meeting with the American Association of Physical Anthropologists was held on March 22, 1932, in the auditorium of the U. S. National Museum. Dr. Carl von Hoffman spoke on the subject, *The wild tribes of Formosa.*

The special meetings of January 5 and February 11, and the regular meetings of January 19 and February 25 were held in the auditorium of the U. S. National Museum. The remaining regular meetings were held in Room 42-32 of the museum building.

The meetings of January 5, January 19, February 11, and February 25, together with that held on December 15, 1931, formed a special series of five lectures relating to the Indian Tribes of western North America.

Frank H. H. Roberts Jr., *Secretary*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

National Academy of Sciences.—The National Academy of Sciences held its regular spring meeting in Washington on April 24, 25 and 26, with sixty-three papers on its program, nine of which were by Washingtonians or by scientists affiliated with Washington institutions. The principal evening lecture was by Dr. Thomas Hunt Morgan of the California Institute of Technology, on *The bearing of genetics on the theory of evolution.*

The Academy dinner, on the evening of Tuesday, April 25, was addressed by Dr. W. W. Campbell, President of the Academy, who called particular attention to the condition of stress and anxiety in many research institutions, due to the curtailment or threatened curtailment of necessary support. He urged that the scientific work of the federal government in Washington should be preserved and continued because the scientific bureaus of the government undertake work of great benefit to the nation which cannot be done by universities or other research institutions.

Medals awarded by the Academy were: the Alexander Agassiz Medal to Dr. Albert Defant of the Institut für Meereskunde, Berlin; the Public Welfare Medal to Dr. William H. Park of New York City; the John J. Carty Medal and Award, a newly established honor of the Academy, posthumously to Dr. John J. Carty; the Henry Draper Medal to Dr. V. M. Slipher, Lowell Observatory, Flagstaff, Ariz.; and the Mary Clark Thompson Medal to Dr. Francis Arthur Bather, of Wimbledon, England. Fourteen persons were elected to membership in the Academy.

An outstanding event of the Academy meeting was the demonstration concert by the Philadelphia Symphony Orchestra, on the evening of Thursday, April 26, at Constitution Hall. It was played in Philadelphia, transmitted to Washington by three special telephone circuits, and reproduced on the stage by three loudspeakers, with Director Leopold Stokowsky at the controls. In addition to the rendition of a full concert, with volume and tonal effects quite beyond the reach of an orchestra as ordinarily conducted, the audience was treated to an explanatory lecture by Dr. Harvey Fletcher, of the Bell Telephone Laboratories, who also demonstrated some of the mechanics of the extraordinary sound control made possible by the method.

American Philosophical Society.—Several Washington scientists presented papers at the meeting of the American Philosophical Society, which met at Philadelphia on April 20, 21 and 22. Dr. Ales Hrdlicka of the U. S. National Museum spoke on *The forehead: its esthetic and anthropological values.* The subject of Matthew W. Stirling, Chief of the Bureau of Ethnology, Smithsonian Institution, was *Jivaro Shamanism.* Dr. Elmer A. Harrington of the U. S. Bureau of Standards presented a report on *Further experiments on the continual generation of heat in certain silicates.* Three members of the staff of the Carnegie Institution of Washington also read papers. They were:

Dr. ALFRED V. KIDDER, on *Mayan explorations and their results;* Dr. FRANCIS G. BENEDICT, on *Human gaseous metabolism in atmospheres of pure oxygen;* and Dr. OSCAR RIDDLE, on *Differentiating some functions of anterior pituitary hormones.*

American Geophysical Union.—The fourteenth annual meeting of the American Geophysical Union was held at the building of the National Academy of Sciences, on April 27, 28 and 29. Jointly with the Union, the Eastern Section of the Seismological Society of America also held its meeting, part of the sessions taking place at Georgetown University. A full program of papers was presented. During the meeting, on Friday noon, April 28, Rev. JAMES B. MACELWANE, S.J., of St. Louis University, broadcast a radio talk on *Earthquakes, what are they?* over the nationwide network of the Columbia Broadcasting System, under the auspices of Science Service.

American Meteorological Society.—The American Meteorological Society met on the morning of Saturday, April 29, at the U. S. Weather Bureau. An outstanding feature of its program was a paper by Prof. LARS VEGARD, professor of physics at the Kongelige Frederiks University, Oslo, on *The aurorae and the high strata of the atmosphere.* Prof. Vegard also presented papers before the National Academy of Sciences, and the American Geophysical Union.

Other Scientific Meetings.—During late April and early May Washington was host to the Acoustical Society of America, the American Physical Society, the Horological Institute of America, the Catholic Anthropological Conference, and a group of seventeen medical, surgical and psychiatric societies.

Sigma Xi.—The annual dinner and meeting of the Washington chapter of the Society of Sigma Xi was held at the University Club on the evening of Tuesday, May 9. Dr. ALEXANDER T. WETMORE of the U. S. National Museum was elected president for the ensuing two-year period. The meeting was addressed by Dr. PAUL R. BARTSCH of the U. S. National Museum. Dr. Bartsch also spoke before the Sigma Xi Club of George Washington University on the evening of Monday, May 15.

At Georgetown University School of Medicine.—Dr. O. S. GIBBS, Professor of Physiology at the School of Medicine, University of Georgia, has been appointed Professor of Physiology and Chairman of the Department of Physiology. Dr. Gibbs has recently carried out very interesting researches on the nature of autonomic hormones. He has shown that certain drugs and chemicals are able to inhibit the enzyme which normally destroys the parasympathetic substance, acetyl-cholin, in the blood. Thus if eserin, for example, is injected into the blood stream and then the parasympathetic nerve to the salivary glands is stimulated one obtains not only increased salivation but also inhibition of the heart. (Because the acetyl-cholin is now not destroyed by the blood for the destructive enzyme is neutralized by eserin.)

Dr. WALLACE M. YATER, Professor of Medicine, discovered the first known cases of congenital heart-block due to anatomical discontinuity of the conductive system of the heart: the bundle of His. Dr. Yater has also been using thorium dioxide for x-ray examination of the spleen and arteries.

Professor GEORGE A. BENNETT of the Department of Anatomy has been investigating the effect of thorium dioxide on tuberculous guinea pigs. He

finds that certain strains of bacilli which cause only localized lesions in the lungs become more destructive and produce generalized tuberculosis if the animal has been previously treated by thorium dioxide.

Dr. THEODORE KOPPANYI, of the Department of Pharmacology, and his associates discovered a very specific and sensitive test for veronal and its derivatives. This test already has found wide clinical application. Also this test made it possible for the first time in the history of pharmacology to follow the fate of the drug in the human and animal body and account for almost every milligram injected.

Dr. J. BAY JACOBS of the Department of Obstetrics investigated the effects of the much discussed new drug, dilaudid, in labor and found that it possesses no advantages over morphine.

Present Papers on Mammalogy.—Papers by five members of the Bureau of Biological Survey were presented at the fifteenth annual meeting of the American Society of Mammalogists, held at the Biological Institute of Harvard University, in Cambridge, Mass., May 9 to 13. A paper by VERNON BAILEY dealt with *The importance of types and type localities in the study of mammals* and one by E. A. GOLDMAN discussed *The isolation factor in the evolution of species.* Dr. H. H. T. JACKSON, a member of the society's board of directors, spoke on *Preservation of teeth of larger mammals.* The title of an address by Dr. T. S. PALMER was *Are there sixty thousand antelope in the United States and Canada?* Illustrated with slides, a paper by CHAS. C. SPERRY, of the Bureau's Denver (Colo.) food-habits research laboratory, dealt with the subject, *Fall food habits of coyotes, a report of progress, 1932.* FREDERIC WINTHROP, JR., of the Museum of Comparative Zoology, spoke on *A collecting trip Across Northern Mexico,* made last winter in company with VERNON BAILEY, of the Biological Survey. The report was illustrated with motion pictures and slides. The Biological Survey was also represented by its associate chief, W. C. HENDERSON, and by E. A. PREBLE, chairman of the society's editorial board, and Mrs. VIOLA S. SNYDER, treasurer of the society.

VERNON BAILEY, chief field naturalist of the Biological Survey, was elected president of the society for the coming year.

NEWS BRIEFS

The construction of the building and dome of the new 15-inch photographic refractor of the Naval Observatory is nearly completed. The objective, of the triplet type, is being made by ROBERT LUNDIN and the mounting by Warner and Swasey.

During the months of March and April, ALBERT E. SCARLETT, of Mount Vernon, N. Y. (amateur radio station W2CC), through whom radio messages from the Watheroo Magnetic Observatory in Western Australia are received, succeeded in establishing a long record for daily contacts with H. M. COOPER, Glenelg, South Australia (VK5HG). By April 13, he had succeeded in securing sixteen or seventeen such contacts without a miss, a remarkable feat considering the low power of both stations.

The following officers were elected at the 54th Annual Meeting of the Biological Society of Washington on April 29:—*President,* C. E. CHAMBLISS; *Vice-Presidents,* C. W. STILES, T. E. SNYDER, H. C. FULLER, T. H. KEARNEY; *Recording Secretary,* S. F. BLAKE; *Corresponding Secretary,* JOE

S. Wade; *Treasurer,* F. C. Lincoln; *Members of Council,* W. R. Maxon, A. A. Doolittle, I. N. Hoffman, E. P. Walker, J. Shillinger.

Personal Items

Commander R. S. Patton has been appointed head of the U. S. Coast and Geodetic Survey. Commander Patton has been connected with the Survey since 1904.

Professor Elliot R. Clark of the University of Pennsylvania delivered an address to the faculty and students of the School of Medicine, George Washington University on Saturday, April 29. Dr. Clark's subject was *Spontaneous activity of capillaries.*

Dr. J. S. Ames, chairman of the National Advisory Committee for Aeronautics has appointed Dr. H. C. Dickinson of the U. S. Bureau of Standards chairman of the special subcommittee on standardization of methods of rating aircraft engines. One of the principal functions of this subcommittee will be the correlation of requirements for the testing of civil and military aircraft engines.

J. A. Fleming, acting director, Department of Terrestrial Magnetism, represented the Carnegie Institution of Washington at the dedication of the George Eastman Research Laboratories of the Massachusetts Institute of Technology on May 1.

Director Horace M. Albright of the U. S. National Park Service, was one of the principal speakers at the first camp exposition of the Washington Y.M.C.A. the evening of May 6. Dr. Harold C. Bryant, Assistant Director, showed lantern slides of parks and monuments.

Earl A. Trager, geologist in the Washington office of the U. S. National Park Service, is now in Chicago installing the national parks and monument exhibits at the Century of Progress. In addition to the Service's exhibit in the Government Building there will be eight dioramas in the Hall of Science displaying the earth sciences as exemplified in the national parks. These eight dioramas were prepared at Park Service Field Headquarters in Berkeley under the direction of Senior Park Naturalist and Forester Ansel F. Hall.

Verne E. Chatelain, historian, and Frank A. Kittredge, chief civil engineer of the U. S. National Park Service, recently visited the Morristown Historical Park area to investigate development needs and to look into the matter of suitable boundary lines.

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OF THE

WASHINGTON ACADEMY OF SCIENCES

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Manuscripts may be sent to any member of the Board of Editors: they should be clearly typewritten and in suitable form for printing without essential changes. The editors cannot undertake to do more than correct obvious minor errors. References should appear only as footnotes and should include year of publication. To facilitate the work of both the editors and printers it is suggested that footnotes be numbered serially and submitted on a separate manuscript page.

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JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 23 JULY 15, 1933 No. 7

CRYSTALLOGRAPHY.—*The ray-surface, the optical indicatrix, and their interrelation: An elementary presentation for petrographers.*[1] GEORGE TUNELL, Geophysical Laboratory, Carnegie Institution of Washington.

INTRODUCTION

The definitions of terms and the treatments of the elementary principles of optical crystallography in American text-books are in some respects unsatisfactory from the viewpoint of the petrographer. Clear and accurate statements are to be found in Pockels's "Lehrbuch der Kristalloptik," published in 1906. But Pockels's statements of elementary theory are scattered through mathematical discussions of more advanced problems, and for this reason apparently they have not received the attention that they deserve from American students of petrography. In order to make this material more readily available, the two fundamental theorems of optical crystallography are restated in this paper in very simple geometrical form without mathematical equations, and some of the chief applications of these theorems in petrography are discussed. A new geometrical construction is given for the first theorem in the case of biaxial crystals that is equivalent to the construction of Pockels but is simpler and much more easily visualized in practical applications.

ISOTROPIC SUBSTANCES

In substances belonging to the isometric system of crystallization or other isotropic substances, light of a single color emanating from a point-source radiates in all directions with equal velocities; at the end of unit time light of a single color will have traveled the same distance from the central point-source along each *ray*. The surface to which light has spread along all the rays is a sphere and this surface

[1] Received April 18, 1933.

is known as the *ray-surface*.[2] This surface is also sometimes called the *wave-surface*[3] because it represents the light wave that has spread out from the point-source as it exists for an instant at the end of unit time. In the present form of the wave theory the waves of light are electromagnetic waves, and the light is propagated in the form of transverse, electromagnetic vibrations. In isotropic crystals all directions perpendicular to a given ray-direction are possible *vibration directions* of rays having the given ray-direction.

UNIAXIAL SUBSTANCES

In crystals of the tetragonal and hexagonal systems, light of a single color traveling in any ray-direction oblique to the crystallographic c-axis has two different ray-velocities; moreover one of these ray-velocities varies with the direction. The ray-surface of such crystals consists of an ellipsoid of revolution and a sphere internally or externally tangent to it at the ends of the rotation-axis of the ellipsoid. The radii of the ray-surface represent the distances to which light travels along the rays in unit time. This two-sheeted surface is also sometimes called the wave-surface because it represents the double light-wave that has spread out from a point-source as it exists for an instant at the end of unit time. The vibration direction of any ray belonging to the spherical part of the ray-surface (such a ray is called an ordinary ray) is perpendicular to a section through the ray-surface containing the ray under consideration and the rotation-axis of the ray-surface (such a section is called a principal section of a uniaxial crystal). The vibration direction of any ray belonging to the ellipsoidal part of the ray-surface (such a ray is called an extraordinary ray) lies in the principal section and is assumed in the electromagnetic theory[4] to be parallel to the plane tangent to the ray-surface at the

[2] This statement and the remainder of this discussion apply to crystals without rotatory power. For petrographers, consideration of crystals with rotatory power is relatively unimportant, as Rosenbusch and Wülfing have stated. Those who desire information concerning the ray-surfaces of crystals with rotatory power, which are more complicated than the ray-surfaces of crystals without rotatory power, should consult Pockels's "Lehrbuch der Kristalloptik," pp. 307–309, also p. 332 (paragraph at top of page).

[3] This is the usage of Pockels, Wright, and nearly all other authors; Johannsen, however, applies the term wave-surface to a different surface (one to which it seems much less appropriate).

[4] At the present time it is no mere academic suggestion that petrographers adhere to the usage of the term vibration direction that is consistent with the electromagnetic theory. In the first place the only physical significance that can be attached to the basic concepts of optical crystallography today comes from the electromagnetic theory. In the second place, refractive indices and orientations of numerous anisotropic substances have recently been calculated approximately from a knowledge of their crystal structures by means of the electromagnetic theory. Such calculations are not intended to replace direct measurements of refractive indices, but are of great importance in correlating the different branches of crystallography—geometrical, optical, and structural.

end of the extraordinary ray under consideration. Thus in general the vibration direction of an extraordinary ray is not perpendicular to the ray.[5]

Geometrically associated with each ray is a *wave-front*. The wave-front of an ordinary ray is a plane perpendicular to the ray, since the ray-surface of the ordinary rays is a sphere. The wave-front of an extraordinary ray, however, is not perpendicular to it in general, but is a plane tangent to the ray-surface at the end of the extraordinary ray in question (that is, tangent to the ellipsoidal part of the ray-surface); this tangent plane is only normal to the extraordinary ray if the extraordinary ray be parallel or perpendicular to the rotation-axis of the ray-surface. The perpendicular distance from the central point-source of light to any plane wave-front (plane tangent to the ray-surface) is the measure of the velocity of the wave. Along the rotation-axis of the ray-surface all rays travel with the same velocity; moreover the wave-normals associated with these rays coincide with the rays in direction and the velocity of the waves is equal to the velocity of the rays. This direction of the ray-surface (the rotation-axis) is called the optic axis, and crystals of the tetragonal and hexagonal systems are called uniaxial because they have one (and only one) optic axis.

By definition the *refractive index* is equal to the reciprocal of the wave-velocity and, in general, it differs from the reciprocal of the ray-velocity.[6,7]

In applications of the theory of optical crystallography to practical problems of mineralogy and petrography, such as the determination of minerals, the directions perpendicular to the wave-fronts (these directions are called *wave-normals*) and the wave-velocities play more important rôles than the ray-directions and the ray-velocities. Thus Wright[8] says that:

[5] For a comparison of the newer usage with the older usage of the term vibration direction based on the solid elastic theory of light see TUNELL, G., and MOREY, G. W. Am. Mineral. **17**: 365. 1932.

[6] This is the usage of Pockels, Wright, Rosenbusch, Wülfing, Niggli, Johannsen, Bouasse, and Duparc and Pearce. With this usage the fundamental law of refraction in anisotropic as well as isotropic crystals is expressed by the equation, $n=\frac{\sin i}{\sin r}$, where n denotes the refractive index, i the angle of incidence of the wave-normal in a vacuum, and r the angle of refraction of the wave-normal in the crystal. If the refractive index be set equal to the reciprocal of the ray-velocity then the refractive index does not enter the fundamental equation of refraction in the case of anisotropic crystals.

[7] The reciprocal of the ray-velocity has been called the ray-index in distinction from the refractive index. BORN, M. *Atomtheorie des festen Zustandes* (*Dynamik der Kristallgitter*) 2nd ed. p. 602. 1923.

[8] WRIGHT, F. E. *The index ellipsoid* (*optical indicatrix*) *in petrographic microscope*

"In rock thin-sections the crystal plates are very thin and most of the observations are made in either central or slightly oblique illumination. Under these conditions it is simpler and more direct to consider only the wave-front normals (i.e. directions perpendicular to the wave-fronts) and to leave the rays entirely out of the discussion. This statement does not mean that the significance of rays should be passed over in silence but simply that for the working petrographer the conception of the wave-front normals is sufficient to explain practically all the phenomena which he encounters."

In practical problems of mineralogy and petrography, as well as in problems of the theory of optical crystallography, it has been found extremely helpful to introduce another reference surface called the *optical indicatrix.* The optical indicatrix of a uniaxial crystal is an ellipsoid of rotation and, unlike the ray-surface, consists of a single sheet. The length of the radius along the rotation-axis of the indicatrix is set equal to the refractive index, ϵ, of an extraordinary wave propagated at right angles to the rotation-axis (all such extraordinary waves have the same refractive index); the length of the equatorial radius of the indicatrix is set equal to the refractive index, ω, of an ordinary wave. Each radius vector of the indicatrix represents a vibration direction and its length is the measure of the refractive index of a wave vibrating along it.

By means of the optical indicatrix one can solve the following two important practical problems very easily, as will be shown in the succeeding paragraphs.

Problem I. Given the direction of a ray, OS, with respect to the optical indicatrix (Fig. 1). Required to find the directions of the two wave-normals associated with it, also the refractive indices of the two waves, and lastly the vibration directions and velocities of the two rays propagated along OS. Construction: Pass a plane through the given ray, OS, and the optic axis, $O\epsilon$ (plane of the paper in Fig. 1). In the plane of the paper draw the diameter conjugate to the ray, OS. (Note. One diameter of an ellipse is conjugate to a second diameter if, and only if, the first diameter be parallel to the tangents to the ellipse at the ends of the second diameter.) Then OP_1, the conjugate to OS, is the vibration direction of the extraordinary ray propagated along OS and the normal to the plane of the paper is the vibration direction of the ordinary ray propagated along OS; moreover the distance, OP_1, represents the refractive index of the extraordinary wave, and the radius of the indicatrix normal to the plane of the paper represents the refractive index of the ordinary wave. Draw the line, ON_1,

work. Am. Journ. Sci. **35**: 135. 1913. With this discussion of Wright the present paper is in complete agreement. Niggli takes the same view. (*Lehrbuch der Mineralogie*, 1. *Allgemeine Mineralogie*. 2nd ed. p. 368. 1924.)

perpendicular to OP_1 in the plane of the paper. The line, ON_1, is the wave-normal of the extraordinary ray and the wave-normal of the ordinary ray coincides with OS. Lastly draw a perpendicular to the elliptical section at P_1; this perpendicular intersects OS in Q_1. Then $\frac{1}{P_1Q_1}$ is the velocity of the extraordinary ray propagated along OS,

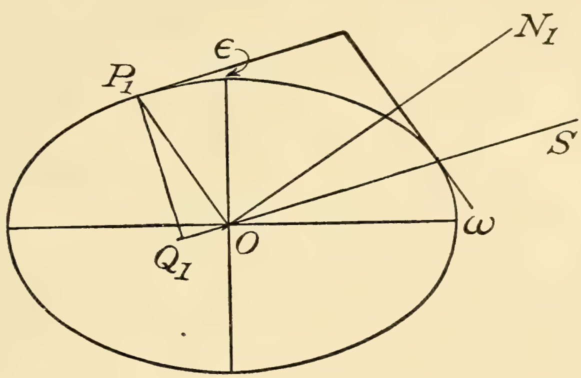


Fig. 1.—Section through the indicatrix of a uniaxial crystal illustrating the construction of Problem I.

and the reciprocal of the radius of the indicatrix normal to the plane of the paper is the velocity of the ordinary ray propagated along OS.

Problem II. Given the direction of a wave-normal, ON, with respect to the indicatrix (Fig. 2). Required to find the refractive indices of the two waves propagated along it, also the directions and velocities of the two rays associated with these two waves, and lastly the vibration directions of the two rays. Construction: Pass a plane through the wave-normal, ON, and the optic axis, $O\epsilon$ (plane of the paper in Fig. 2). In the plane of the paper draw OP_1 perpendicular to ON. Then OP_1 is the vibration direction of the extraordinary ray and the distance, OP_1, represents the refractive index of the extraordinary wave. The radius of the indicatrix perpendicular to the plane of the paper is the vibration direction of the ordinary ray and it also represents the refractive index of the ordinary wave. At P_1 draw the perpendicular to the elliptical section. Through O draw a line normal to the perpendicular from P_1; this normal, OS_1, intersects the perpendicular to the elliptical section in Q_1. Then OS_1 is the direction of the extraordinary ray and $\frac{1}{P_1Q_1}$ is the velocity of the extraordinary ray. The ordinary ray coincides with ON and its velocity is equal to the

reciprocal of the radius of the indicatrix perpendicular to the plane of the paper.

The construction of Problem II solves the standard problem of the determination of the extinction positions and birefringence of a thin-section of a mineral grain observed in approximately parallel light. In this case the incident wave-normal is assumed to be perpendicular to the plane, parallel-sided plate, and passes through the plate with-

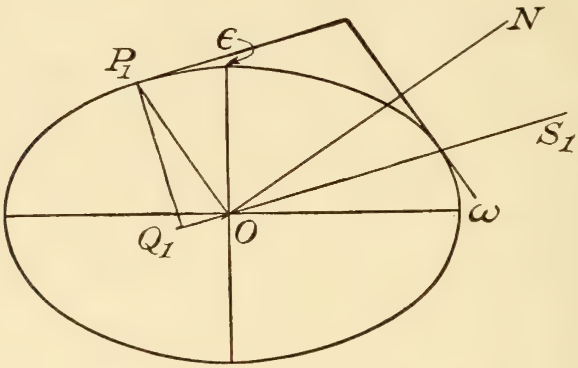


Fig. 2.—Section through the indicatrix of a uniaxial crystal illustrating the construction of Problem II.

out change of direction in accordance with the fundamental law of refraction. In the general case of a wave-normal in an isotropic medium striking an anisotropic crystal plate at any angle, the fundamental law of refraction is as follows:

$$n_0 \sin i = n_1 \sin r_1 = n_2 \sin r_2,$$

where n_0 denotes the refractive index of the isotropic medium, i the angle of incidence of the wave-normal, n_1 and n_2 the refractive indices of the plate for the two refracted wave-normals corresponding to the incident wave-normal, and r_1 and r_2 the angles of refraction of the two wave-normals inside the crystal plate corresponding to the given incident wave-normal. In the special case of a wave-normal incident perpendicularly the angles r_1 and r_2 are both zero; inside the crystal plate two waves are propagated along the given wave-normal with different wave-velocities, however. The vibration directions of the two rays associated with the two waves lie in the plane of the plate. A plane passed through the center of the indicatrix parallel to the plane of the plate intersects the indicatrix in an ellipse, the major and minor diameters of which are the vibration directions of the plate.

The difference in length of the major and minor radii of the ellipse is the measure of the birefringence of the mineral section.

Practical and theoretical problems concerning uniaxial crystals could be solved by means of the ray-surface almost as conveniently as with the indicatrix; the ray-surface of biaxial crystals is much more complicated, however, and the solution of most problems by means of it is impracticable. An oblique section of the ray-surface of a biaxial crystal is not composed of circles and ellipses but of more complicated curves not readily visualized without computation and plotting.

BIAXIAL SUBSTANCES

After the discovery of the form of the ray-surface of uniaxial crystals by Huygens the attempt was made by Young to generalize it and to obtain thus the ray-surface of crystals belonging to the orthorhombic, monoclinic, and triclinic systems (biaxial crystals), but the attempt was not successful. Sometime later, however, Fresnel succeeded in generalizing a single-sheeted reference surface analogous to the indicatrix, and from the generalized single-sheeted reference surface he obtained for the first time the true ray-surface of biaxial crystals.

The indicatrix of a biaxial crystal is a triaxial ellipsoid[9] the dimensions (diameters) of which, measured along the axes, are 2α, 2β, and 2γ, where α, β, and γ denote the principal refractive indices of the substance, $\alpha < \beta < \gamma$. Each radius vector of the indicatrix represents a vibration direction and its length is the measure of the refractive index of a wave vibrating along it. All plane sections passing through the center of the indicatrix of a biaxial crystal are ellipses except two, which are circles. The two circular sections include the intermediate axis of the triaxial ellipsoid (β-axis), and both circular sections have radii of length β. The directions perpendicular to the two circular sections are called the optic axes or binormals. There is a certain analogy between the optic axes of a biaxial crystal and the optic axis of a uniaxial crystal, since all wave-normals coincident with an optic axis of a biaxial crystal have the same refractive indices and have vibration directions in all azimuths in the circular sections; however, the analogy is not complete, since the rays corresponding to these wave-normals do not coincide with the wave-normals, with one exception in the case of the wave-normals along each optic axis.

[9] For the description and equation of a triaxial ellipsoid, see Osgood, W. F., and Graustein, W. C. *Plane and solid analytic geometry.* pp. 548, 549. 1922.

For the equation of the indicatrix of biaxial crystals see Rosenbusch's *Mikroskopische Physiographie der petrographisch wichtigen Mineralien,* 1: Erste Hälfte, 5th ed., Wülfing, E. A. 1 Lief., p. 125. 1921, or Pockels. *op. cit.*, p. 33.

In the indicatrix of a biaxial crystal, as in the indicatrix of a uniaxial crystal, a ray drawn in a random direction, the wave-normal associated with the ray, the vibration direction belonging to the ray and wave-normal, and also the perpendicular to the indicatrix at the

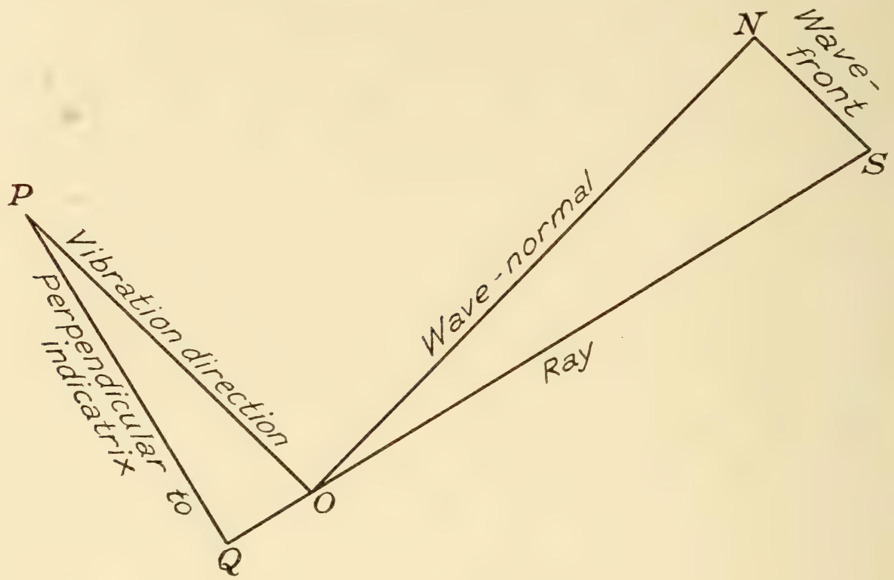


Fig. 3.—A ray drawn in a random direction, the wave-normal associated with the ray, the vibration direction common to the ray and the wave-normal, and the common perpendicular to the ray and the indicatrix at the end of the radius representing the vibration direction all lie in a plane. Legend: *OS*, ray; *ON*, wave-normal; *OP*, vibration direction; *PQ*, common perpendicular to ray and indicatrix at end of radius representing vibration direction.

end of the radius representing the vibration direction all lie in a plane; moreover the perpendicular to the indicatrix at the end of the radius representing the vibration direction is also perpendicular to the ray (Fig. 3).[10] Thus by means of the indicatrix one can solve two problems, I′ and II′, for biaxial crystals by constructions analogous to those already explained for uniaxial crystals. The problems and solutions are as follows.

Problem I′. Given the direction of a ray, *OS*, with respect to the optical indicatrix (Fig. 4). Required to find the directions of the two wave-normals associated with it, also the refractive indices of the two waves, and lastly the vibration directions and velocities of the two rays propagated along *OS*. Construction: Pass a plane through

[10] Pockels, F. *op. cit.*, pp. 48, 52, 53. Fletcher, L. *The optical indicatrix and the transmission of light in crystals.* pp. 32, 50, 51, 52. 1892.

the center of the indicatrix conjugate to the given ray, OS. (Note. A diametral plane is conjugate to a given diameter of a triaxial ellipsoid if, and only if, it be parallel to the planes tangent to the ellipsoid at the ends of the given diameter.)[11] The conjugate plane intersects the indicatrix in an ellipse (which in two special cases reduces to a circle); the major and minor diameters of this ellipse, P_1P_1' and P_2P_2', are the vibration directions of the two rays propagated along OS, and the distances, OP_1 and OP_2, represent the refractive indices of the two

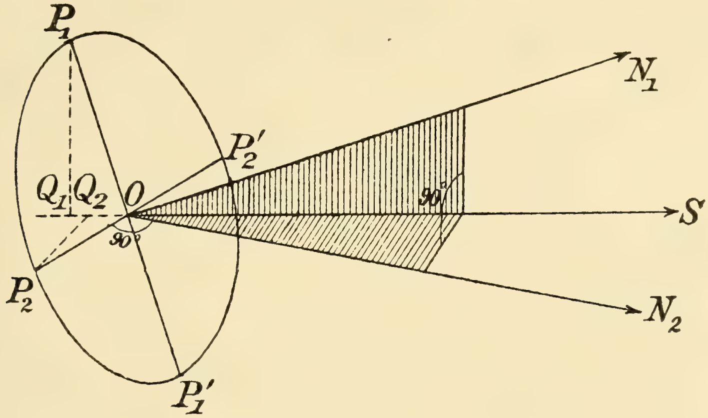


Fig. 4.—Perspective drawing of the construction of Problem I′.

waves associated with the two rays. The wave-normal corresponding to the ray propagated along OS and vibrating along P_1P_1' lies in a plane through OS and P_1P_1' and is normal to P_1P_1'. Similarly the wave-normal corresponding to the ray propagated along OS and vibrating along P_2P_2' lies in a plane through OS and P_2P_2' and is normal to P_2P_2'. Draw the perpendiculars to the indicatrix at P_1 and P_2; these perpendiculars intersect OS in Q_1 and Q_2. Then $\frac{1}{P_1Q_1}$ is the velocity of the ray propagated along OS and vibrating along P_1P_1', and $\frac{1}{P_2Q_2}$ is the velocity of the ray propagated along OS and vibrating along P_2P_2'. It may be noted in conclusion that the planes, SON_1 and SON_2, are perpendicular; in other words, the wave-normals, ON_1 and ON_2, lie in perpendicular planes the intersection of which is OS. P_1Q_1

[11] Osgood, W. F., and Graustein, W. C. *op. cit.*, Unnumbered exercise immediately following Theorem 1 on page 570, also Theorems 3 and 4 on page 571. Or alternatively, Salmon, George A. *A treatise on the analytic geometry of three dimensions.* (Revised by Rogers, R. A. P. 5th ed. 1: 90. 1912.

and P_2Q_2 also lie in the planes, SON_1 and SON_2, respectively, and P_1Q_1 and P_2Q_2 are both perpendicular to OS.[12]

Problem II′. Given the direction of a wave-normal, ON, with respect to the indicatrix (Fig. 5). Required to find the refractive indices of the two waves propagated along it, also the directions and velocities of the two rays associated with these two waves, and lastly the

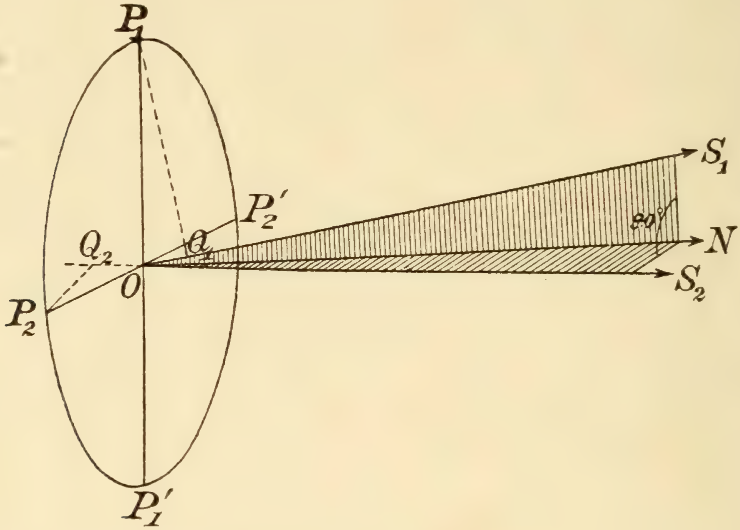


Fig. 5.—Perspective drawing of the construction of Problem II′.

vibration directions of the two rays. Construction: Pass a plane through the indicatrix perpendicular to the given wave-normal, ON. This plane intersects the indicatrix in an ellipse (which in two special cases reduces to a circle); the major and minor diameters, P_1P_1' and P_2P_2', of this ellipse are the vibration directions of the two rays corresponding to the given wave-normal, and the distances, OP_1 and OP_2, represent the refractive indices of the two waves propagated along ON. At P_1 and P_2 draw lines perpendicular to the indicatrix. Through

[12] The construction given in Problem I′ is based on that of Pockels (*op. cit.* p. 54) and arrives at the same results, but reaches the results by a slightly different and considerably simpler route. Thus in the construction given here the elliptical section containing the vibration directions is obtained as a diametral section parallel to the tangent plane at the end of the given ray, whereas in Pockels's book the elliptical section is obtained as the plane section containing all the points of tangency of a cylinder the elements of which are parallel to the given ray. The construction used here has a very substantial advantage in practical problems since the tangent plane at the end of the given ray and the diametral plane parallel to this tangent plane are readily visualized as soon as the indicatrix and ray are given, whereas the tangent cylinder is difficult to visualize and even if pictured correctly offers relatively little aid to one's geometrical intuition in locating the desired elliptical section.

O draw lines normal to the perpendiculars from P_1 and P_2; these normals, OS_1 and OS_2, intersect the perpendiculars to the indicatrix in Q_1 and Q_2. Then OS_1 and OS_2 are the directions of the two rays corresponding to the two waves propagated along ON and vibrating along OP_1 and OP_2 respectively. The velocities of the rays, OS_1 and OS_2, are equal to $\frac{1}{P_1Q_1}$ and $\frac{1}{P_2Q_2}$ respectively. It may be noted in conclusion that the planes, NOS_1 and NOS_2, are perpendicular; in other words, the two rays, OS_1 and OS_2, lie in perpendicular planes the intersection of which is ON; moreover the vibration directions, OP_1 and OP_2, lie in the planes, NOS_1 and NOS_2, respectively. The lines, P_1Q_1 and P_2Q_2, also lie in the planes, NOS_1 and NOS_2, respectively, but, unlike OP_1 and OP_2, the lines, P_1Q_1 and P_2Q_2, are not themselves perpendicular in this case.[13]

The ray-surface[14] of a biaxial crystal can easily be developed from the indicatrix by means of the constructions given in Problem I′. A picture of a model of the ray-surface of a biaxial crystal (after Johannsen) is given in Fig. 6. In particular the principal sections of the ray-surface are readily deduced. In the plane of the indicatrix, $\beta\gamma$, two rays are propagated along each radius. One of these rays has the velocity, $1/\alpha$, in every direction in the plane, $\beta\gamma$, and gives rise to a circle. The other of these rays has a velocity that varies with the direction in the plane, $\beta\gamma$, from a minimum of $1/\gamma$ to a maximum of $1/\beta$, and gives rise to an ellipse. This ellipse lies wholly within the circle in the plane, $\beta\gamma$, since $1/\alpha > 1/\beta > 1/\gamma$. In the plane, $\alpha\beta$, two rays are propagated along each radius. One has the velocity, $1/\gamma$, in every direction in the plane, $\alpha\beta$, and gives rise to a circle. The other has a velocity that varies with the direction in the plane, $\alpha\beta$, from a minimum of $1/\beta$ to a maximum of $1/\alpha$, and gives rise to an ellipse. This ellipse lies wholly outside the circle in the plane, $\alpha\beta$, since $1/\alpha > 1/\beta > 1/\gamma$. In the plane, $\alpha\gamma$, also, two rays are propagated along each radius. One has the velocity, $1/\beta$, in every direction in the plane, $\alpha\gamma$, and gives rise to a circle. The other has a velocity that varies with the direction in the plane, $\alpha\gamma$, from a minimum of $1/\gamma$ to a maximum of $1/\alpha$ and gives rise to an ellipse. The ellipse and the circle in the plane, $\alpha\gamma$, intersect, since $1/\alpha > 1/\beta > 1/\gamma$, and their four common points are lettered u, u', u'', and u''' in Fig. 9. In the directions, uu' and $u''u'''$, there is only a single ray-velocity since the points, u, u',

[13] Based on the construction of Pockels. *op. cit.*, p. 54.

[14] For the equation of the ray-surface of biaxial crystals, see ROSENBUSCH and WÜLFING. *op. cit.*, p. 124, or POCKELS. *op. cit.*, p. 41.

u'', and u''' are common to both sheets of the ray-surface. The directions, uu' and $u''u'''$, are called the ray-axes or biradials. In most crystals the angle between an optic axis (binormal) and the adjacent

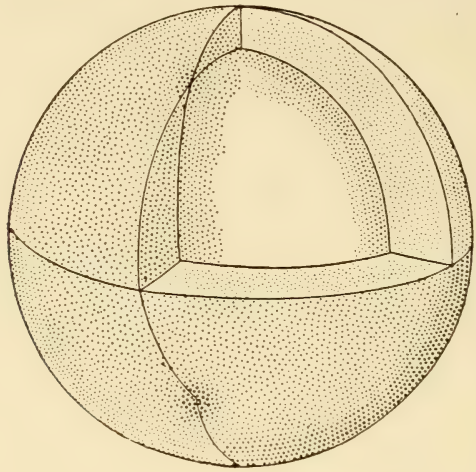


Fig. 6.—Model of the ray-surface of a biaxial crystal. (After Johannsen.)

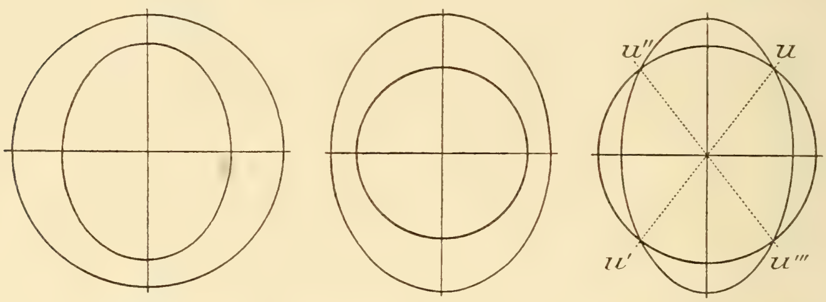


Fig. 7 Fig. 8 Fig. 9

Figs. 7, 8, 9.—Principal sections of the ray-surface of a biaxial crystal. In Fig. 7 the plane of the drawing is the plane, $\beta\gamma$, and the direction of the major diameter of the ellipse is that of the γ-axis; the direction of its minor diameter is that of the β-axis. In Fig. 8 the plane of the drawing is the plane, $\alpha\beta$, and the direction of the major diameter of the ellipse is that of the β-axis; the direction of its minor diameter is that of the α-axis. In Fig. 9 the plane of the drawing is the plane, $\alpha\gamma$, and the direction of the major diameter of the ellipse is that of the γ-axis; the direction of its minor diameter is that of the α-axis.

ray-axis (biradial) is very small, but the optic axes and the ray-axes do not coincide.

In theory it is true of biaxial crystals as well as of uniaxial crystals that all information obtainable from the indicatrix could be obtained

from the ray-surface (stated in another way, either of these two surfaces can be derived from the other); nevertheless in most problems the required quantities are more easily constructed from the indicatrix than from the ray-surface.

As Wright[15] has clearly pointed out, the indicatrix is more closely and directly connected with the experimental observations made in most petrographic work than any other reference surface. In such work, either with thin-sections or with powders immersed in liquids, the measurements of refractive index (by comparisons of refractive indices of two adjacent substances the index of one of which is known) are made with the aid of a polarizing prism.[16] Thus refractive indices are obtained bound together with the corresponding vibration directions. These measurements and observations are simply and unambiguously stated in terms of the properties of the indicatrix; on the other hand statements of these results in terms of the properties of the ray-surface are involved and confusing. One may mention the following typical example: Under the microscope one observes elongated crystals of an unknown mineral and finds by means of the central illumination or oblique illumination test, that its greatest refractive index, γ, is measured when the longest dimension of the crystals is parallel to the vibration direction of the polarizing prism;[17] then one knows that the γ-direction of the indicatrix is parallel to the longest dimension of the crystals. If it be next ascertained by measurement of interfacial angles (or coordinate angles of faces) with the reflection goniometer, by the measurement of interfacial angles with the Fedorov stage, or by measurement of interzonal angles with the microscope stage[18] that the longest dimension of the crystals is the crystallographic c-axis, one can write finally, $\gamma = c$. The determination of the orientation of the other two principal axes is accomplished and recorded in a similar manner. The determination of the orientation of crystals of the triclinic system requires a somewhat more complicated

[15] *Op. cit.*, pp. 133–138.

[16] For a discussion of the various immersion methods and references to explanations of their modes of application, see Tunell, G., and Morey, G. W. Am. Mineral. **17**: 372–378. 1932.

[17] It is assumed here that only one polarizing prism is in the path of light through the microscope, the second polarizing prism being thrown out of the optical path.

[18] In the measurement of interzonal angles, that is, the angles between crystal edges, under the microscope, care must be taken to establish the parallelism of the plane containing the two edges with the microscope stage. This can be accomplished by the observation that both edges in question are sharply in focus throughout their entire lengths simultaneously; it can also be accomplished in special cases by observation of the interference figures of the crystals in convergent light. If the plane of the two edges be not parallel to the stage, the angle turned by the stage will not be the true interzonal angle and the measurement will be erroneous.

procedure and is most readily accomplished by means of the Fedorov stage.[19]

ACKNOWLEDGMENT

The author is indebted to Dr. H. E. Merwin and Dr. Tom. F. W. Barth for several valuable suggestions.

[19] For an excellent statement of the method of determining the orientation of the optical indicatrix of any substance with respect to the crystallographic axes by means of the Fedorov stage, see DUPARC, L., and REINHARD, M. *La détermination des plagioclases dans les coupes minces.* Mém. Soc. de Physique et d'Histoire Naturelle de Genève. **40**: 72–101. 1924.

MINERALOGY.—*Properties of tri-calcium silicate from basic open hearth steel slags.*[1] OLAF ANDERSEN and HARLEY C. LEE. (Communicated by ROBERT B. SOSMAN.)

A study of the constitution of slags was taken up by the writers at the Research Laboratory of the United States Steel Corporation several years ago.[2] In the course of our work, we succeeded in collecting samples containing relatively large individuals and sometimes well developed crystals of all the essential constituents of the slags. Since data on such constituents are meager and because any additional data will improve the accuracy of the microscopic work and will facilitate the future investigation of slags, we have taken advantage of the good material at our disposal and have devoted some time to coordinated determinations of the physical and chemical properties of most of the constituents of the slags. Chemical analyses have been made of the pure constituents separated from the slags and optical and other physical properties have been determined on material from corresponding samples. Whenever possible, crystallographic measurements have also been made. The complete results of our work are not yet ready for publication, but we find it of interest to report separately on our study of one of the constituents, tri-calcium silicate,[3] $3CaO \cdot SiO_2$.

Received June 10, 1933.

One of us (Lee) left the Research Laboratory of the United States Steel Corporation in 1931 and has since continued his work on slags intermittently at the Department of Mineralogy of the Ohio State University.

[3] After the completion of much of our work on the tri-calcium silicate about a year ago (May 1932) we were informed by Dr. John Johnston, Director of the Research Laboratory of the U. S. Steel Corporation, that Dr. A. Guttmann, Director of the Forschungsinstitut des Vereins deutscher Eisenportlandzementwerke in Düsseldorf, was interested in obtaining for his cement investigations a sample of slag containing tri-calcium silicate. Accordingly we sent Dr. Guttmann some of our material and jointly with Dr. Gille he has made a thorough study of it and is now anxious to publish his results without interfering with our interests. It is for this reason that we publish our results on the tri-calcium silicate without awaiting the conclusion of the work on

The slag.—The most suitable material for our investigations was obtained from the interior of large masses of slag (several tons) which had been tapped into ladles in the ordinary routine of steel making. Along the contacts with the ladle and at the exposed surface of such a slag, a solid crust will form quickly while inside the crust the cooling goes on very slowly and the slag may retain some of its volatile constituents till the last stage of the crystallization. These conditions are favorable for the growth of comparatively large and well developed crystals.

TABLE 1

ANALYSIS OF BASIC OPEN HEARTH SLAG CONTAINING TRI-CALCIUM SILICATE (JANITZKY)

SiO_2	11.70
TiO_2	0.38
P_2O_5	1.65
Al_2O_3	1.28
Fe_2O_3	4.54
FeO	14.87
MnO	8.70
MgO	9.36
CaO	46.59
S	0.20
Total	99.27

The constitution of the slags will not be described in detail in this paper. The following brief statements give the main features of composition and structure.

Analyses of basic open hearth slags of the type containing tri-calcium silicate as an essential constituent have been published by E. J. Janitzky,[4] whose samples are included among those studied by us. These analyses represent quickly cooled samples collected directly from the furnace. The slowly cooled slags from which we obtained our material for crystallographic and optic measurements were of the same type as those collected by Janitzky and have compositions close to that given in Table 1.

The main constituents of the slags dealt with are di-calcium silicate

the other slag constituents. The first part of Guttmann and Gille's paper, containing introductory discussions of cement problems, has been published in "Zement" for April 1933 under the title: *Zementtechnische Bedeutung und Feinbau des Trikalziumsilikats*. The remaining part will appear in the same journal Nr. 28 (July 13, 1933). We have been informed in advance of the results of their investigation and we have likewise communicated our results to them by sending them a copy of the manuscript of this paper.

[4] Yearbook American Iron and Steel Institute 1929, pp. 414–434. In Table 1 of Janitzky's paper the analyses marked Heat No. 1 2, 5, and 7 represent slags rich in tri-calcium silicate.

($2CaO \cdot SiO_2$) and tri-calcium silicate ($3CaO \cdot SiO_2$); important are also periclase (MgO), a magnetic oxide, and a lime-bearing ferrite; less important are crystallized lime (CaO), apatite (lime phosphate) and a constituent of uncertain composition, perhaps a modification of di-calcium silicate. Occasionally fluorite (CaF_2) is observed in slags to which much of this mineral has been added.

The constituents are not, as a rule, pure compounds, but usually solid solutions of two or more compounds one of which is predominating. Thus the lime silicates contain manganese and iron compounds and other admixtures, the periclase contains a considerable amount of iron oxides (magnesioferrite) in solid solution, and the magnetic oxide is a complex mixture of compounds.

The aggregates formed by these constituents vary considerably in composition and structure even within the same sample, and these variations clearly depend upon several factors besides rate of cooling. Some parts of a sample of slag may for instance contain abundant tri-calcium silicate together with di-calcium silicate, periclase, etc., while other parts of the same sample may consist largely of di-calcium silicate and periclase. In the latter case the residual liquid, from which tri-calcium silicate would usually crystallize, has been drained away from the loosely coherent aggregates of early crystals. Some parts of the slag may be compact and others vesicular, and the cavities sometimes contain constituents, such as apatite, that may not occur in the compact parts. The vesicular parts and the crystals occurring in the cavities have evidently been formed under the influence of volatile constituents retained in the slag, while the compact parts have crystallized from relatively dry melts. In many samples it is seen that the heavy crystals of oxide, formed at an early stage of the crystallization, have settled in the remaining melt and the bottom parts of such samples are therefore relatively rich in these oxide crystals. The rapidly cooled parts of a slag are relatively fine grained and often show a radial structure with thin plates of tri-calcium silicate arranged in sub-parallel or fan shaped groups (Figs. 1, 2, and 3). The slowly cooled parts are more coarse grained and have a more equant development of the crystal individuals (Figs. 4, 5, and 6). The tri-calcium silicate appears to have been among the last constituents to crystallize in the cavities as well as in the compact parts of the slag. It contains inclusions of the other constituents (Figs. 3, 4, 5, and 6).

Composition.—Material for the chemical analysis was obtained by mechanical separation of tri-calcium silicate from a coarse-grained

sample of slag. The crushed sample was classified into three fractions, −140+200 mesh (0.105-0.074 mm.), −200+325 mesh (0.074-0.044 mm.) and −325+400 mesh (0.044-0.039 mm.) and each fraction was treated individually in the following way: The magnetic constituents (oxide, periclase, and ferrite) were first removed by running the sample through a magnetic separator.[5] The non-magnetic residue consisted largely of a mixture of di-calcium silicate and tri-calcium silicate. By repeating the separation several times this mixture could be obtained almost free from magnetic impurities. The two silicates were

TABLE 2

Analysis of Tri-Calcium Silicate Extracted from a Basic Open Hearth Slag

ANALYST: ELIZABETH KEEDICK LEE

SiO_2	22.77
TiO_2	0.18
P_2O_5	1.72
Al_2O_3	0.20
Fe_2O_3	0.76
FeO	2.01
MnO	1.20
MgO	1.29
CaO	68.65
Total	98.78
Gain on ignition	0.3

then separated by a heavy liquid consisting of methylene iodide slightly diluted with carbon tetrachloride (spec. gravity about 3.24). In this liquid the tri-calcium silicate would just float and the di-calcium silicate would sink together with other heavier impurities such as free lime and traces of the magnetic constituents. By repeated separations a material consisting of at least 98 per cent tri-calcium silicate and having di-calcium silicate as the only impurity of importance was obtained. We found that by proceeding as described we got better results than by making the separation directly in the heavy liquid without first extracting the magnetic constituents (all of which are heavy and therefore would sink together with di-calcium silicate). After the separation the three fractions of grain sizes of tri-calcium silicate were mixed. We had about 8 gr. of material for the analysis. The results are given in Table 2.

While the analysis shows about 86 per cent $3CaO \cdot SiO_2$ and thus about 14 per cent of impurities in the sample, microscopic examination indicates that about 12 per cent of this material is in solid solu-

[5] We used a modification of the laboratory separator described by Hallimond, A. F. Min. Mag. **22**: 377–381. 1930.

tion in the tri-calcium silicate. Some idea of the large amount of material originally in solid solution can be had by referring to Fig. 14.

Crystallographic properties—Previous investigators have been in doubt with regard to the symmetry of the crystals. E. S. Shepherd,[6] and G. A. Rankin and F. E. Wright,[7] who first proved that tri-calcium silicate was a homogeneous compound, had only fine grained aggregates at their disposal and consequently could not obtain any definite data on the crystallographic properties. Certain observations on the optical properties made them think that the crystals possibly were monoclinic.

The numerous investigations of tri-calcium silicate as a constituent of Portland cement have made no appreciable addition to our knowledge of the crystallographic and optic properties of the compound,[8] because all these investigations have also been undertaken on fine-grained aggregates. It was not till the discovery of tri-calcium silicate in basic slags[9] that crystals of reasonable size were obtainable. Thus J. M. Ferguson[10] described crystals up to 5 mm. in diameter, without giving, however, crystallographic measurements or complete optical data. Ferguson thought that the crystals probably were orthorhombic.

For our crystallographic measurements we succeeded in picking out from the slags about 20 crystals ranging in size from 0.5×0.5×0.1 mm. to 3.0×3.0×0.5 mm. Some of these were only fragments, however, and none gave perfect signals for all faces on the same crystals. Nevertheless a sufficient number of coordinated measurements have been made to prove that the crystals belong to the trigonal system and have a rhomobohedral development. Most of the crystals examined, including all those measured for the determination of the axial ratio, came from the same sample from which the material for analysis was also extracted.

The most prominent form on all crystals (Figs. 7–10) is the basal pinacoid $C(0001)$. One or two rhombohedrons are also always present,

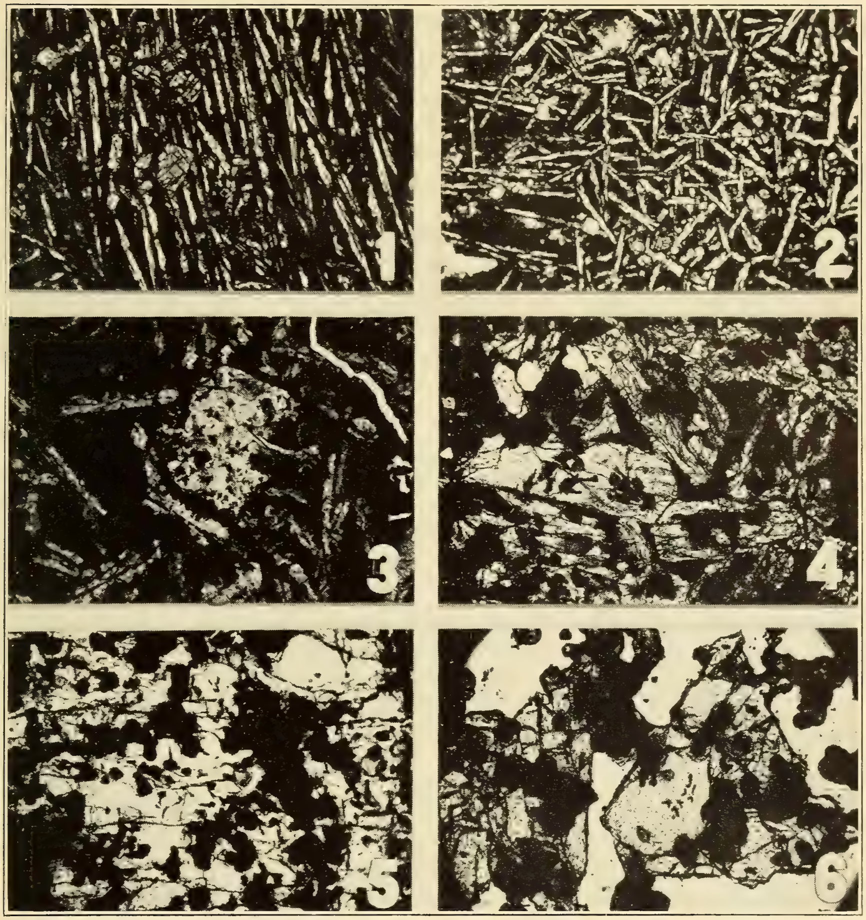
[6] Shepherd, E. S., Rankin, G. A. and Wright, F. E. Journ. Ind. and Eng. Chem. **3**: No. 4. 1911. Also in Zeitschr. f. Anorg. Chem. **71**: 20–44. 1911.

[7] Rankin, G. A. and Wright, F. E. Amer. Journ. Sc. (4) **39**: 1–79. 1915.

[8] For a review of the literature up to 1926 see: Bogue, R. H. *A digest of the literature on the constitution of Portland cement clinker*. Paper No. 3. Portland Cement Association Fellowship of the National Bureau of Standards, Washington, D. C. (Reprints from "Concrete" July 1926 to February 1927.) References to later publications are given by Guttmann and Gille (See footnote (3).)

[9] Dr. Wm. McCaughey, Professor of Mineralogy at the Ohio State University, has applied petrographic methods to the study of slags for many years and has probably been the first to observe tri-calcium silicate in slags.

[10] Royal Techn. College Met. Club Journal, **6**: 9–12. 1927–28. Glasgow.



Figs. 1–6. Basic open hearth slags. Photomicrographs of thin sections. Ordinary light. Black areas represent ferrite and oxide, white or light gray areas largely tri-calcium silicate. Fig. 1—42×. Cross sections of thin plates of tri-calcium silicate. Round grains with cleavage lines: Periclase and lime. Fig. 2—30×. Plates of tri-calcium silicate in cross sections and a few in basal sections. Round or square spots, some with cleavage cracks: Periclase. Fig. 3—42×. Hexagonal basal section of tri-calcium silicate, with inclusions of oxide, surrounded by cross sections. Fig. 4—35×. Cross sections of thick crystal plates of tri-calcium silicate showing base and rhombohedrons. Fig. 5—35×. Large individual of tri-calcium silicate with inclusions of di-calcium silicate (slightly darker) and oxide (black). Fig. 6—35×. Triangular basal section (right) and cross section (left) of tri-calcium silicate with inclusions of di-calcium silicate (dark gray) and oxide (black). White areas: Voids in section.

but no other forms have been observed. One of the rhombohedrons is generally more conspicuous than the other and is present on all crystals. We have selected this as a positive rhombohedron, $R(10\bar{1}1)$. The

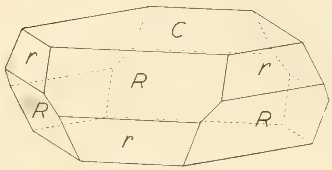


Fig. 7

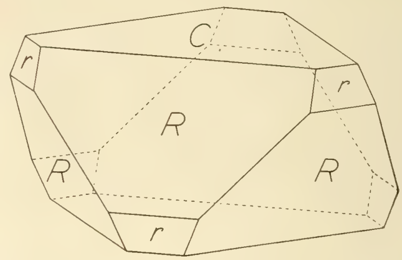


Fig. 8

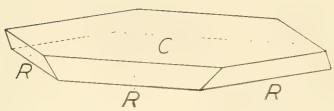


Fig. 9

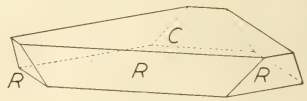


Fig. 10

Figs. 7–10. Crystal habits of tri-calcium silicate. Forms: $C(0001)$, $R(10\bar{1}1)$ and $r(\bar{2}021)$.

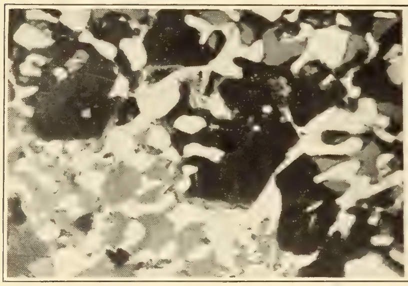


Figure 11.

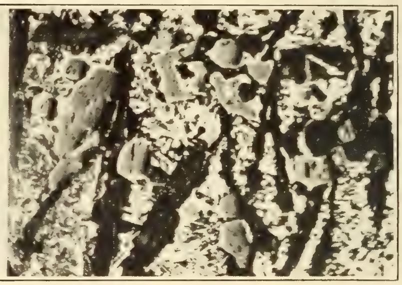


Figure 12.

Basic open hearth slags. Photomicrographs of polished surfaces. Fig. 11—67×. Dry objective. Surface etched with water. Black areas, some with hexagonal outlines: Tri-calcium silicate. Gray: Di-calcium silicate. White or very light gray: Periclase, oxide and ferrite. Fig. 12—100×. Oil immersion. Surface not etched. Black bands: Tri-calcium silicate. Other black areas: largely di-calcium silicate. Light gray areas with white rims: Periclase with oxide mantles. White: Oxide and ferrite.

other one, which is missing on some crystals and is very insignificant on others, then becomes the steeper negative rhombohedron $r(\bar{2}021)$. The characteristic zone relations of the various faces of these forms will appear from Figs. 7 and 8.

The axial ratio $c:a = 1.7730$, calculated with the setting selected, agrees with that indicated by x-ray measurements. The crystallographic calculation is based on the average value for the angle $C(0001):R(10\bar{1}1)$. The angles measured and those calculated from

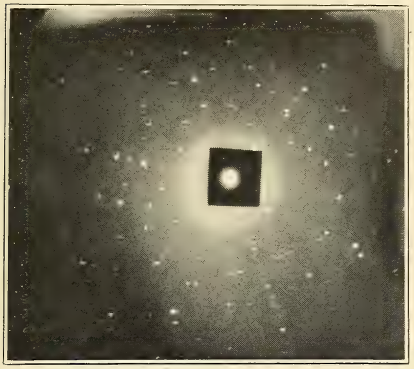


Fig. 13.—Laue photograph of tri-calcium silicate with x-ray nearly parallel to the c-axis. Reduced to one half of original photograph.

Fig. 14.—About 300×. Photomicrograph of clear tri-calcium silicate grain after reheating to 900°C showing lamellae of calcium ferrite formed by unmixing of solid solution.

TABLE 3

Crystal Angles of Tri-calcium Silicate

Angles	Measured: Number of angles measured	Measured: Limits	Measured: Mean	Calculated
$C(0001):R(10\bar{1}1)$..........	23	63° 48′ 64° 8′	63° 58′	
$C(0001):r(\bar{2}021)$..........	8	76° 8′ 76° 19′	76° 15′	76° 17′
$R(10\bar{1}1):R(1\bar{1}0\bar{1})$.........	3	77° 45′ 77° 46′	77° 45′	77° 49′
Angles $C:R$ in three different zones of one crystal....			64° 4′ 64° 0′ 64° 1′	
Azimuth angles between three zones $C:R$ on one crystal, measured on two-circle goniometer..			119° 58′ 120° 1′ 120° 1′	120° 0′

the axial ratio are given in Table 3. Of these measurements those stated in the lower part of the table give ample proof of the trigonal symmetry of the crystals.

The most common habits of the crystals are those shown in Figs. 7 and 8, representing thick basal plates with distinct development of the faces of both rhombohedrons. Less common in the slowly cooled slags, but evidently universally present in rapidly chilled samples, are the very thin basal plates of the types shown in Figs. 9 and 10. Both these have only one rhombohedron, R, but they differ in the development of the faces. In the crystal represented in Fig. 9 there has been an equal development of all faces of the rhombohedron and the plates consequently have hexagonal outlines. In the crystal of Fig. 10, on the other hand, the growth has been more rapid in one direction of the c-axis than in the other, and a triangular development of the plates has resulted. No indication of twinning is seen on any of the crystals examined.

With regard to the class of symmetry to which the tri-calcium silicate may belong, the crystallographic data give no final information. Neither could we obtain etching figures sufficiently distinct for a decisive conclusion. All that can be stated is that nothing in our crystallographic observations contradicts the assumption that the crystals have the symmetry of the di-trigonal scalenohedral class, the class to which most trigonal crystals belong.

We have studied the structure of these tri-calcium silicate crystals by means of x-ray diffraction patterns, using both the Laue and the fine powder method. While we have not completely worked out the crystal structure, our preliminary work indicates that the unit cell is rhombohedral. The x-ray data also indicate that the crystallographic axial ratio of $c:a=1.773$, is probably the correct ratio for the unit cell.

We have included a Laue photograph of one of the clear dark green crystals (Fig. 13) showing the rhombohedral symmetry. The photograph was taken with a molybdenum target with a tube potential of 30,000 volts. The plate to crystal distance in this case was 5 centimeters.

Physical properties—The crystals have a poor cleavage parallel to the base, barely visible in thin sections (Figs. 4 and 5). They are very brittle and often full of cracks and have an uneven fracture. The hardness is slightly higher than 5, but lower than 6.

The specific gravity was determined with a pycnometer on the

material prepared for analysis and on another preparation from the same sample of the slag. Since water attacks tri-calcium silicate the powder was imbedded in α-monobromnaphthalene. The values found were $d\left(\frac{30°}{4°}\right) = 3.233$ and 3.215. The mean, $d\left(\frac{30°}{4°}\right) = 3.224$, may be regarded as representing the crystals described in detail in this paper. Other samples gave slightly different values.

The natural color of the crystals collected from slowly cooled slags is light olive green or brown. The fine powder is light gray with a brownish tinge caused by the numerous inclusions; the streak is light gray, almost white. The faces of fresh crystals have a glassy lustre, but when exposed to moist air for some time they become dull or sometimes iridescent.

Crystals occurring in lime lumps collected directly from the furnace and therefore quickly cooled, were dark olive green and almost perfectly clear and free from inclusions. When such clear crystals were heated for one hour in an electric furnace in air at 900°C they developed oriented lamellae (Fig. 14). These inclusions are reddish brown in color, are anisotropic, have a high index of refraction, and resemble dicalcium ferrite in appearance.

When these crystals are heated for about one hour at 1000°C some small di-calcium silicate crystals are found in the tri-calcium silicate grains. Crystals heated in air on platinum at 1400°C consist mostly of beta di-calcium silicate with some free lime. Part of the beta di-calcium silicate sometimes inverts to the gamma form on cooling.

The greenish color is probably due to ferrous iron compounds in solid solution in the tri-calcium silicate. On heating in air, this iron oxide is apparently oxidized to the ferric state and precipitated as a calcium ferrite.

The formation of a calcium ferrite compound due to oxidation with the resulting change in equilibrium, may explain the formation of di-calcium silicate at low temperatures in these crystals.

Optical properties. Appearance in thin sections.—Thin sections or small grains of the tri-calcium silicate are colorless in transmitted light. Thick sections, crystal plates or large grains are light yellow or brownish with an olive tinge. No pleochroism is observed. When mounted in Canada balsam the sections have a high relief and a pitted surface (Figs. 4, 5, 6). They have many irregular fractures and sometimes show fairly regular cleavage cracks parallel to the elongation of cross sections of the tabular crystals (vibration direction ω).

In thin sections of the slag most of the grains of tri-calcium silicate appear to be perfectly homogeneous except for the easily recognized inclusions of the other constituents of the slag. No twinning is observed, and all the homogeneous grains that have orientations suitable for conoscopic observation show decidedly uniaxial interference figures in accordance with the crystallographic properties described above. Some of the grains, however, contain irregular areas showing negative biaxial interference figures with small, variable axial angles and grading insensibly over into the surrounding uniaxial areas. The same phenomenon is more distinctly observed in thick crystal plates imbedded in an immersion liquid. In such plates some of the biaxial areas are seen to have sharp boundaries against the uniaxial areas and appear to represent inclusions of thin, irregular lamellae of foreign crystals in the tri-calcium silicate. The properties of these inclusions cannot be accurately determined, but they have a refractive index only a little different from that of tri-calcium silicate and a birefringence much higher. The inclusions are colorless and may show a faint indication of irregular twinning. These properties agree with those of di-calcium silicate in one of its high-temperature modifications and we believe that the assumption of such lamellar inclusions give a reasonable explanation of the optical anomalies of the tri-calcium silicate.[11] Considering the nature of the material in which the tri-calcium silicate occurs and its mode of formation the presence of lamellae of di-calcium silicate intimately intergrown with it should not be surprising. Since the amount of lamellae necessary to produce optical anomalies of the nature described is very insignificant (a small fraction of one per cent would certainly be sufficient) these inclusions can hardly influence the results of the analysis to any appreciable extent.[12] Neither can they have any measurable effect on the general physical properties of the crystals. Accordingly we find that the biaxial interference figures shown by parts of the crystals give no reason to postulate a deviation of the symmetry of the crystals from that of the trigonal system and to assume a monoclinic or orthorhombic symmetry with pseudo-uniaxial development such as has been done by previous investigators. The biaxial interference figures may be explained as an optical anomaly in the way indicated and it should be

[11] Any thin double refractive lamella (except one of a uniaxial crystal perpendicular to the optic axis) when superimposed on a basal section of a uniaxial crystal, will distort the interference figure and may easily produce the semblance of a biaxial figure.

[12] An admixture of one per cent $2CaO \cdot SiO_2$ would produce a deviation of about 0.1 per cent CaO and SiO_2 from the figures for pure $3CaO \cdot SiO_2$ and its influence would thus be within the limits of error of an ordinary analysis.

emphasized that such anomalies have been frequently observed in many other crystals the true uniaxial symmetry of which is generally accepted (for instance apatite, beryl, and zircon).

The crystals of tri-calcium silicate were too small and brittle to permit the grinding of prisms for the most accurate determination of the

TABLE 4

REFRACTIVE INDICES OF TRI-CALCIUM SILICATE (MEASURED ON ANALYZED SAMPLE)

$\lambda(10^{-7}$ cm)	ω	ϵ
535.1 (Tl)	1.733	1.728
589.3 (Na)	1.724	1.719
670.8 (Li)	1.714	1.709

refractive indices, but good determinations of the birefringence $(\omega - \epsilon)$ and of the index for the ordinary ray (ω) could be made nevertheless.

The birefringence was determined on plates perpendicular to the base, measuring the path difference with the Berek compensator and the thickness with a micro-caliper. It was found to be 0.005 ± 0.0005

TABLE 5

REFRACTIVE INDICES OF VARIOUS SAMPLES OF TRICALCIUM SILICATE

ω_{Na}	ϵ_{Na}
1.722	1.717
1.726	1.720
1.732	1.726

for all wave lengths between red and violet. The index ω was determined in immersion liquids on plates and grains by Merwin's dispersion method.[13] Various determinations, made on crystals and grains from the same sample that furnished material for the crystallographic measurements and the analysis, gave results in agreement with one another within the limits of error of the method (± 0.001). These results are stated in Table 4. It is seen that there is a considerable dispersion of the refractive indices. The indices for sodium light are somewhat higher than those found by Wright[6,7] on pure tri-calcium silicate (average index for white light approximately 1.715, birefringence not higher than 0.005). This is naturally explained by the fact that the crystals examined contain small amounts of manganese and ferrous compounds, and other admixtures, in solid solution.

Besides the determinations stated above, we have made numerous scattered determinations of refractive indices on material from vari-

[13] MERWIN, H. E. and LARSEN, E. S. Amer. Journ. Sci. (4) **34**: 42–47. 1912. POSNJAK, E. and MERWIN, H. E. Journ. Amer. Chem. Soc. **44**: 1970. 1922.

ous other samples the crystals of which were not analyzed and could not be measured crystallographically. Examples of some of these determinations are given in Table 5. The quite considerable variation in these indices must clearly be due to variations in the composition of the crystals, probably largely in the amounts of ferrous and manganese compounds taken up by the tri-calcium silicate. Possibly the presence of comparatively large amounts of lamellar intergrowths of di-calcium silicate may have something to do with these variations.

Appearance in polished surfaces.—The examination of polished surfaces of slags under the microscope in reflected light may give valuable information supplementing the data obtainable with the petrographic microscope. This is especially true with regard to the opaque or semi-opaque constituents of the slag, but also the transparent constituents may be profitably studied in reflected light when all the possibilities of the method are taken advantage of. We have used this method extensively in our work on the constituents of steel slags and record here briefly our observations on tri-calcium silicate. The identification of the constituents on polished surfaces has always been verified in thin sections or powdered preparations of the same sample.

On polished surfaces that have not been exposed to moisture for any length of time, or on surfaces polished on a dry cloth, there is no very clear distinction between tri-calcium silicate and the other silicates of the slags. They all show the same gray color when observed with a dry objective and all appear practically black with occasional dots of interior reflections when an oil immersion objective is used. Sometimes crystal outlines against constituents having a different reflecting power may be seen. This is the case in the surfaces represented in Figs. 11 and 12.

In Fig. 12 the tabular crystals of tri-calcium silicate are seen in cross sections with an immersion objective. Besides the long black bands representing tri-calcium silicate there are other black areas, some irregular and some with rounded outlines. Most of these represent di-calcium silicate and except for the outlines of the grains there is no sure way of distinguishing the two constituents. In order to bring out the difference clearly etching must be used.

Fig. 11 represents an etched surface showing basal sections with hexagonal outlines of a number of crystals of tri-calcium silicate. The observation is made with a dry objective and the contrast between tri-calcium silicate and di-calcium silicate is brought out by the etching. The reagent in this case was distilled water applied to the surface

for about ten minutes at room temperature. This treatment produces on the surfaces of tri-calcium silicate a film showing vivid interference colors and makes the polishing scratches reappear. At the same time the grains of di-calcium silicate show almost no effect of the etching and appear with the original smooth surface and gray color of reflection. A prolonged etching with water, however, will affect also the di-calcium silicate and will bring out its twinning structure. The same may be accomplished more quickly by using other reagents such as 5 or 10% solutions of NH_4Cl in water, or of weak acids like perchloric acid and chromic acid. Merely dipping the polished surface into one of these solutions will produce striated films on the grains of di-calcium silicate while the tri-calcium silicate will become dull with a dark pitted surface in reflected light.

The relief in polished surfaces is very nearly the same for tri-calcium silicate, di-calcium silicate, and the lime-bearing ferrite. All these constituents appear with a low surface against which the grains of periclase, lime, and magnetic oxide stand out in high relief. The ferrite has a relatively high power of reflection (almost white with dry objective) and so has the oxide. The power of reflection of lime is medium (light gray) and that of periclase variable depending upon its contents of iron oxides (from gray to almost white).

Thus each one of the constituents has its characteristic properties (only a few of which are indicated above) by which it can be distinguished from the others on polished surfaces. It is of particular interest to emphasize here that the tri-calcium silicate can be recognized on polished surfaces and especially that it can be distinguished from its most important associate, the di-calcium silicate.

ACKNOWLEDGMENTS

We are greatly indebted to Mrs. Elizabeth Keedick Lee for having made a careful analysis of the tri-calcium silicate for us. To Dr. Wm. McCaughey, Chairman of the Department of Mineralogy of the Ohio State University, our thanks are due for the kind interest he has taken in our work by placing the facilities of the Department at the disposal of one of us (Lee) and by giving us some of his samples of slag and supporting us with advice and help. We are also indebted to Messrs. C. L. Kinney, E. J. Janitzky and M. J. Devaney of the Illinois Steel Company and Mr. H. B. Siddall of the American Bridge Company for helpful cooperation in obtaining most of the samples used in this investigation. Mr. Nicholas Bryker has given us valuable assistance throughout our work.

PALEONTOLOGY.—*Report on species of corals and larger foraminifera collected in Cuba by O. E. Meinzer.*[1] THOMAS WAYLAND VAUGHAN, Scripps Institution of Oceanography, LaJolla, Calif.

PREFATORY NOTE

This paper furnishes a setting for the list of fossils published under the title, "Report on species of fossils collected in Cuba by E. O. Meinzer in November and December, 1915" by T. Wayland Vaughan,[2] as an appendix to Doctor Meinzer's article "Geologic reconnaissance of a region adjacent to Guantanamo Bay, Cuba."[3]

It is essential for its proper interpretation and was intended to precede that list. It contains an account of the nomenclature of the species involved, the characterization of a new variety, and the discussion of problems of broad regional geologic correlation.

INTRODUCTION

Descriptions of species of corals and foraminifera collected by Dr. Meinzer have appeared in several papers. The Tertiary corals were described by me (Vaughan, 1919), and those descriptions, identifications, and stratigraphic references stand except that the foraminifera from locality 7522 are Eocene, while the corals seem to be Oligocene. My identification of *Diploastrea crassolamellata* from it has been confirmed by Mr. J. W. Wells. Specimens from two horizons appear to have been mixed by the transportation of specimens from a higher to a lower horizon.

Doctor Cushman published the first account of the larger foraminifera (Cushman, 1919) and later I discussed them in two papers (Vaughan, 1924 and 1926). I have endeavored to make a careful restudy of the Cuban material. The task was a difficult one. Since the examinations were based largely on thin sections of organisms that exhibit bewildering variation. I have been led to change some of Doctor Cushman's identifications. Table 1 is taken from Cushman's work already cited.

NOMENCLATURE OF SPECIES

Except to place the species referred to "*Orthophragmina*" in the older genus *Discocyclina*, those species are not changed. The species referred to *Carpenteria* are also left as they were. *Lepidocyclina perun-*

[1] Received May 19, 1933.
[2] This JOURNAL, 23: 261–263. 1933.
[3] Idem, pp. 246–260.

TABLE 1. DISTRIBUTION OF OTHER CUBAN FORAMINIFERA ACCORDING TO STATIONS AT WHICH FOUND

		3448	3473	3475	3478	3567	7512	7513	7516	7518	7519	7521	7522	7543	7548	7554	7664	7666	6117	6118	6119	6120	6122	6123	6124	6125
Orthophragmina	*cubensis* Cushman	×		×		×												×	×	×	×	×	×	×	×	×
	subtaramellei Cushman			×														×?			×	×		×	×	×
	sculpturata Cushman				×																					
	crassa Cushman			×															×	×	×		×	×	×	×
	pustulata Cushman	×			×	×																				
Lepidocyclina	*crassata* Cushman						×	×			×	×														
	perundosa Cushman				×																					
	subraulinii Cushman				×													×								
	morgani Lem. & R. Douv.							×	×		?		?	×		×										
	schlumbergeri Lem. & R. Douv.						×			×			×	×			×									
	marginata (Micht.)						×	?		×	×	×	?	×			×									
	sumatrensis (Brady)							×	×		×			×		×	×									
	canellei var. *yurnagunensis* Cushman													×	×											
Carpenteria	*proteus* Cushman																	×								
	americana Cushman							×		×		×	×				×									

dosa and *L. subraulinii*, both Eocene species, also remain as they were, but the other identifications of *Lepidocyclina* are changed.

Lepidocyclina canellei var. *yurnagunensis* is considered a valid species and I have redescribed it as *Lepidocyclina yurnagunensis* Cushman (Vaughan, 1926). The specimens identified by Cushman as *Lepidocyclina sumatrensis* and *L. morgani* are now referred to *L. yurnagunensis*. The specimens identified as *L. morgani* have both embryonic and equatorial chambers similar to those of *L. yurnagunensis*, but differ by possessing strongly developed pillars. There is complete intergradation between the forms without and with the pillars. In order to indicate the deviation from the typical form of the species, I propose to call this variant *Lepidocyclina yurnagunensis* var. *morganopsis*, n. var. (co-types from loc. 7543). Externally the specimens resemble *L. morgani* and also *L. parvula* Cushman, but as stated above the embryonic and equatorial chambers are like those of *L. yurnagunensis*.

Lepidocyclina crassata Cushman, at least part of the specimens identified by Cushman as *L. marginata* Micht., and *L. chattahoocheensis* Cushman (Cushman, 1920), are all placed in the synonymy of *L.* (*Eulepidina*) *favosa* Cushman (Cushman, 1919, Vaughan, 1924). The names *L. crassata* and *L. favosa* were published by Cushman at the same time, but I am selecting *L. favosa* as the name of the species because specimens free from the matrix can be obtained at the type locality of *L. favosa*, and the type of *L. crassata* is embedded in rock. The amount of variation in this species is most astonishing. Fortunately I have had available hundreds of perfectly preserved specimens from a single bed at one locality, Espinal, Vera Cruz, Mexico, in addition to good representations of all forms from their respective type localities. The specimen from locality 7522 identified by Doctor Cushman as *L. crassata* does not belong to the species.

The specimens identified by Cushman from Doctor Meinzer's localities nos. 7512, 7518, and 7543 as *L. schlumbergeri* are now referred to other species. Some of the specimens represent *L. gigas* Cushman. The specimens collected by Doctor Darton at locality 7664 belong to a large species of the subgenus *Eulepidina* distinct from *L. gigas*.

Doctor Meinzer's collections of orbitoidal foraminifera from localities 7512, 7513, 7516, 7518, 7519, 7543, 7548, 7552, 7553, and 7554, are all of approximately the same horizon in the Oligocene. This horizon is represented in Antigua, Jamaica, Cayman Brac, the State of Vera Cruz in Mexico, and at other localities in the Caribbean and

Gulf of Mexico regions. The horizon of locality 7521 is doubtful. It may be Eocene.

Locality 7522. The foraminifera are definitely Eocene. It contains two or more species in common with the Eocene exposure at Nuevitas, Cuba, U.S.G.S. loc. 3478, and species represented at other Eocene localities in Cuba. The corals collected at this locality seem to have come from another, an Oligocene, horizon.

If I noticed specimens of *Globigerina* and nullipores I recorded their presence. The presence of nullipores, if they are *in situ*, indicates relatively shallow water, because they are photosynthetic organisms; while the presence of *Globigerina* indicates that pelagic organisms drifted into the locality where the other fossils were found.

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BOTANY.—*Several more fungi that prey on nematodes.*[1] CHARLES DRECHSLER, Bureau of Plant Industry.

A fungus with long, narrow, straight or somewhat curved conidia, provided with 5 to 15 septa (Fig. 16 A) and borne on erect, aerial, only slightly differentiated hyphae, usually singly (Fig. 16, A, *a*) but sometimes, following continued growth of the hypha, in small number (Fig. 16 A, *b*), was found actively destroying slender nematodes referable to a species of *Rhabditis*. The animals were snared in rather small, intramatrical, non-constricting hyphal loops (Fig. 16, B) attached singly at a noticeable swelling in one of the three component cells by a relatively delicate, often somewhat curving stalk. Often the organ of capture was torn from its attachment by the struggling nema (Fig. 16, C, *a*), which then was frequently further snared in one or two other hyphal loops before finally succumbing to extensive internal hyphal invasion (Fig. 16, C, *b*). This invasion regularly proceeded

[1] Received June 9, 1933.

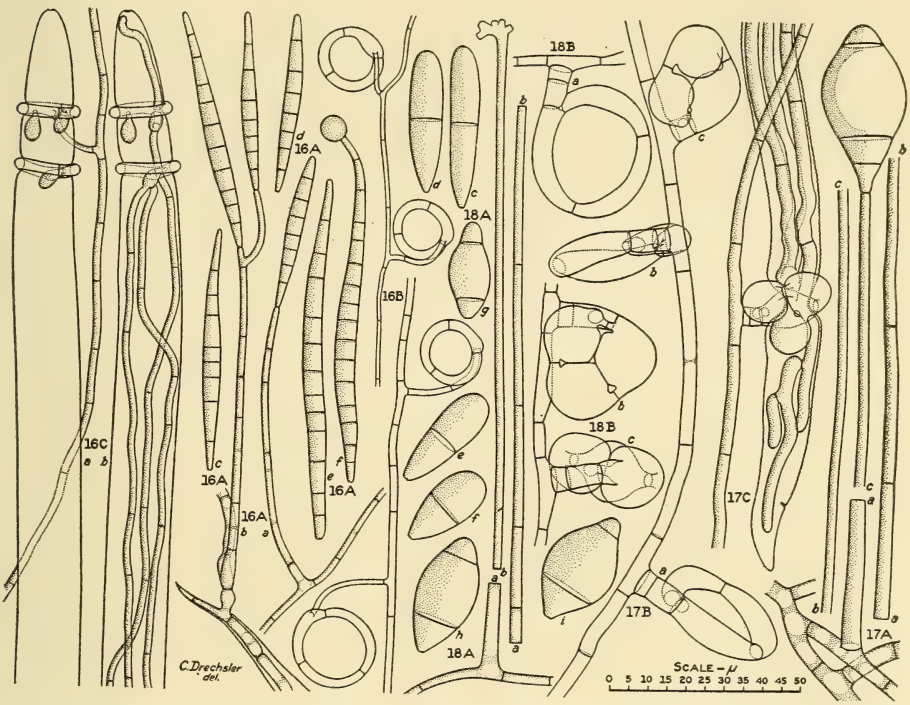
from one or more bursiform outgrowths thrust into the animal immediately following narrow perforation of its integument, the outgrowths being evidently too small to produce serious effects directly.

A fungus bearing terminally on tall, erect conidiophores (Fig. 17, A), solitary, 3-septate conidia strongly resembling in size, shape and septation those of the fungus previously shown in Figure 5,[2] as well as the 3-septate spores frequent in the fungus represented in Figure 12, was found very destructive to nemas referable to the genera *Rhabditis* and *Cephalobus*. The organs of capture here, however, correspond to those produced by the fungi shown in Figures 10, 13 and 14, similarly consisting of mostly vertically oriented, sturdy loops each composed regularly of 3 cells and attached by a short, stout, usually 2-celled stalk, the third loop-cell being fused terminally both to the basal portion of the first loop-cell and to the distal stalk-cell (Fig. 17, B, *a*, *b*); and similarly through pronounced swelling of the loop-cells (Fig. 17, B, *c*) constricting the animal nearly to death before initiating mycelial invasion (Fig. 17,C). The constricting loops here, as also those of the other forms producing them, and as, indeed, even the extensive systems of anastomosing adhesive superficial loops like those produced by the fungus shown in Figure 5, are sometimes torn from their attachments by the struggles of especially vigorous nemas, the uprooted apparatus, nevertheless, just as in the case of the non-constricting solitary loops characteristic of the fungi shown in Figure 6 and 16, usually continuing in its destructive function.

Since organs of capture are generally absent when any of the predacious Hyphomycetes isolated so far (those shown in Figs. 1–7, 9, 12–15, 16–18) are grown in pure culture on agar media of various compositions, it would seem that a tactile stimulus supplied in nature by living nemas, may be of moment for their production. Constricting loops (Fig. 18, B, *a*) in great abundance were produced by a fungus in an agar plate culture free of nematodes but liberally infested with mites. Many of the loops were "sprung" (Fig. 18, B, *b*, *c*), though apparently no mites were captured in them. The fungus in the mite-infested culture gave rise to conidia showing all gradations from an elongated 1-septate type to a strongly inflated 2-septate type (Fig.

[2] As the present summary constitutes a continuation of two earlier summaries concerning nema-capturing fungi, the numbering of the figures is made continuous throughout, so that all citations of figures given herein and bearing numerals from 1 to 11 refer to the first paper (this JOURNAL **23**: 138–141. 1933) and those bearing numerals from 12 to 15 inclusive refer to the second (this JOURNAL **23**: 267–270. 1933).

18, A, *c–i*), thereby abating somewhat the distinctness of the two types of conidia produced by fungi snaring nemas in constricting loops. As in pure culture virtually only spores of the elongated 1-



Three nema-capturing fungi, each numeral denoting a species separate from the others, and all drawn with the aid of the camera lucida at the same magnification; ×500.

Fig. 16.—A, Conidiophores and conidia: *a*, conidiophore of usual type bearing a single conidium; *b*, conidiophore arising from a killed nema and bearing 2 conidia; *c*, *d*, conidia from an agar culture infested with nemas; *e*, *f*, larger conidia from a pure culture. B, Portions of mycelium bearing non-constricting loops. C, A nema snared in two loops: *a*, one of the loops still attached to parent filament, several pouch-like structures thrust into the interior of the animal, the latter still actively struggling; *b*, 5 hours later, both loops detached, mycelial hyphae extending the entire length of the animal, not showing only occasional feeble movement.

Fig. 17.—A, Conidiophore and attached conidium, the former shown in several sections, *a*, *b* and *c* representing corresponding points on these sections. *B*, Portion of mycelium with attached constricting loops, the loops being open in *a* and *b*, and partly closed in *c*. C, Nema captured in constricting loop.

Fig. 18.—A, Conidiophore and conidia from mite-infested culture, the conidiophore drawn in several sections, *a* and *b* representing corresponding points on these sections, *c–i* conidia showing transitions from elongated 1-septate type to inflated 2-septate type. B, Constricting loops from mite-infested culture, *a* in open condition, *b* and *c* in completely closed condition.

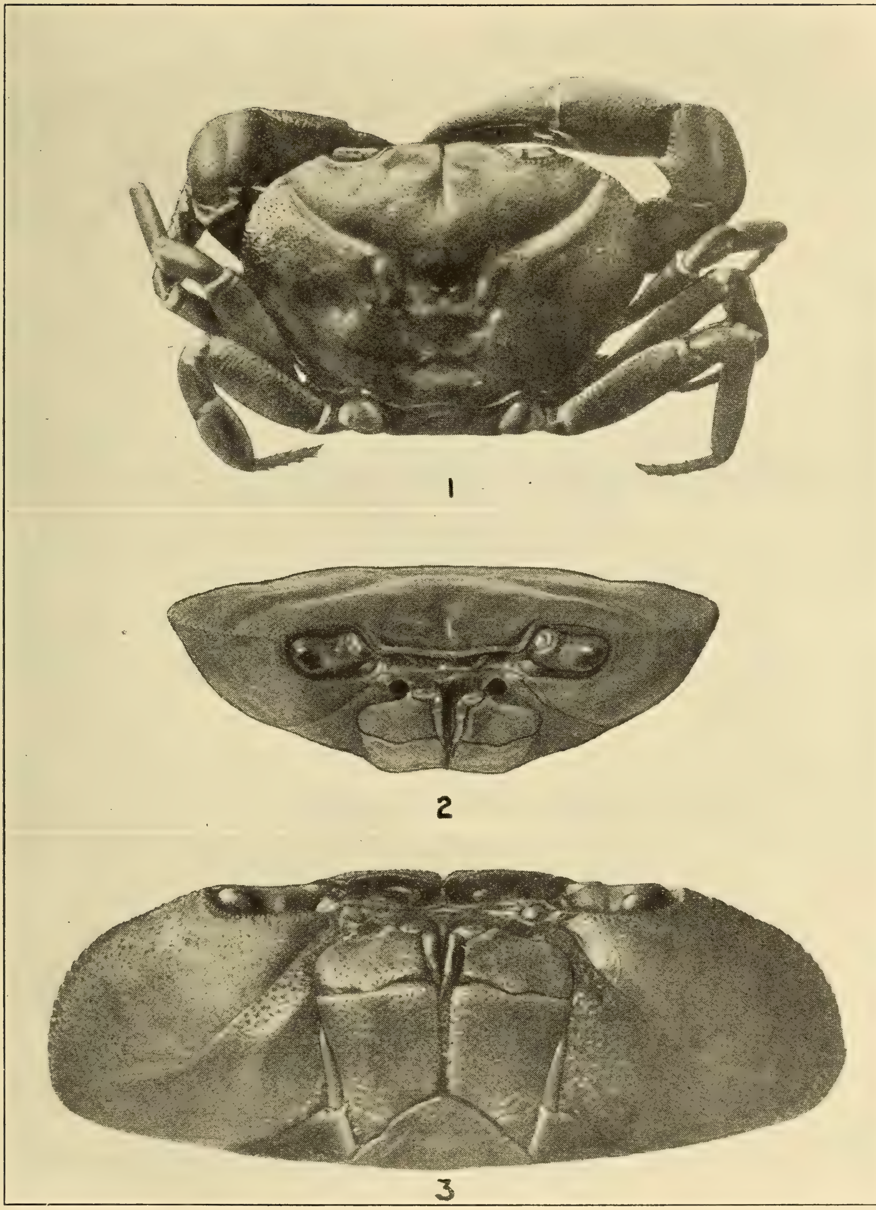
septate type are produced, and as the conidiophores (Fig. 18, A, *a*, *b*) are closely similar to those of the fungus shown in Figure 13, it is not certain that a species separate from the latter is represented here.

ZOOLOGY.—*The generic names* Cephalobellus *Cobb, 1920 and* Scarabanema *Christie, 1931 (Nematoda).*[1] JESSE R. CHRISTIE, Bureau of Plant Industry. (Communicated by G. STEINER.)

Cobb (1920) described *Cephalobellus papilliger* as a new genus and new species of nematode parasite from the larva of an unidentified lamellicorn beetle collected in New South Wales, Australia. He described only the male and no figure was published. Christie (1931) proposed the genus *Scarabanema* describing as type species *Scarabanema cylindricum*, a parasite now known from the larvae of several scarabaeid beetles. In the genus *Scarabanema*, Christie also placed *Thelastoma brevicaudatum* Leidy, 1851 and *Oxyuris leuckarti* Hammerschmidt, 1838. Only the females of these species are known and so far as one can judge from the meager descriptions available, both resemble *Scarabanema cylindricum* rather closely. They differ, however, in the size of the eggs. For the egg of *Thelastoma brevicaudatum*, Leidy gives 1/285 inch long by 1/1000 inch broad, or approximately 89 microns long by 25 microns wide, and for the egg of *Oxyuris leuckarti*, Hammerschmidt gives 1/25 to 1/20 Vienna line long by 1/30 Vienna line wide or approximately 84 to 100 microns long by 70 microns wide. In either case the difference seems too great to fall within the limits of variation for a single species and Christie (1931) deemed it advisable to retain both *Thelastoma brevicaudatum* and *Oxyuris leuckarti* as distinct species placing them in the genus *Scarabanema*.

A comparison of the male of *Cephalobellus papilliger* as described by Cobb (1920) and the male of *Scarabanema cylindricum* as described and figured by Christie (1931) shows no difference which would serve as a basis for retaining the latter as a valid species. Therefore the genus *Scarabanema* Christie, 1931 falls as a synonym of the genus *Cephalobellus* Cobb, 1920 and *Scarabanema cylindricum* Christie, 1931 becomes a synonym of *Cephalobellus papilliger* Cobb, 1920. The genus *Cephalobellus* also contains the following species: *Cephalobellus brevicaudatus* (Leidy, 1851) new combination and *Cephalobellus leuckarti* (Hammerschmidt, 1838) new combination.

[1] Received May 2, 1933.



Figures 1–3. *Pseudothelphusa guerreroensis*, n. sp.

Fig. 1.—Dorsal view, $\times 1\frac{1}{2}$. Fig. 2.—Anterior view of front and orbits, $\times 2$. Fig. 3.—Ventral view of forward half, $\times$nearly 3.

ZOOLOGY.—*A new species of* Pseudothelphusa *from Mexico.*[1] MARY J. RATHBUN, Smithsonian Institution.

Pseudothelphusa guerreroensis, n. sp.

Resembles *P. tuberculata*[2] in its rough surface, crowded but minute denticles on the lateral margin, well marked cervical suture, deep, anterior median suture, widening behind the oblique epigastric lobes; its shallow front, upper margin coarsely granulate and continued backward above the base of the eyestalk; the stout chelipeds, with palms swollen, upper and lower margins convex, and a large tubercle on outer surface at base of fingers. Differs from *tuberculata* in its narrower carapace, proportion of length to width 1:1.51, in *tuberculata* 1:1.6; greater fronto-orbital width in proportion to carapace width, 0.6 as against 0.57 in *tuberculata;* orbits in front view more quadrate, the upper and lower margins nearly parallel, while in *tuberculata*, the orbits are more oval; tooth absent from anterior end of lateral margin of carapace; a small round depression present behind outer angles of front and in horizontal line with extremities of anterior mesogastric outline; ischium of outer maxilliped broad, increasing in width distally but shorter than in *tuberculata*, merus very short and wide; its greatest length only $\frac{2}{3}$ of its width.

P. masimbari,[3] also closely related to the new species, has stronger denticles on the lateral margin, much less prominent epigastric lobes, a front deeper at the extremities and reaching downward to a level with the middle, maxillipeds of the type of *tuberculata*, and moreover lacks a tubercle at distal end of palm.

Type-locality:—Mexico: Malinaltepec, south of Teopa, Guerrero; Prof. L. Schultze, S.J., collector; April 30, 1930; Zool. Mus., Berlin; received through Dr. A. Schellenberg; 1 female holotype (23153, Bn.M.); 1 small female paratype (66850, U.S.N.M.).

[1] Received April 20, 1933. Published with the permission of the Smithsonian Institution.

[2] RATHBUN. Bull. Mus. d'hist. nat. **2**: 60. 1897. Guatemala.

[3] Smithsonian Misc. Coll. **59**: 13. 1912. Canal Zone.

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

Chance to Restore Water Areas.—Unemployment-relief programs may offer a splendid chance to establish water areas for our migratory waterfowl, PAUL G. REDINGTON, Chief of the Bureau of Biological Survey, told the Izaak Walton League of America at its annual convention held recently in Chicago. "Deforestation and erosion, with the resultant depletion of water areas," said Mr. Redington, "have worked no good to man, beast, or fowl. There must be a real renaissance if we are to program a wide intensive effort to build up our diminishing water resources, and I believe that the time now appears ripe to tackle the situation which confronts us in many States." The convention called upon Federal and State officials and the public to begin a far-reaching program to this end and adopted a resolution urging that water restoration be included in the Federal reforestation program.

Wild-Life Exhibit at Chicago Exposition.—To emphasize the need for a permanent program of conservation, the Biological Survey has cooperated with the Department of Agriculture Office of Exhibits in preparing a wild-life exhibit for the Century of Progress exposition in Chicago. Specimens of mammals and birds have been mounted in a scene representing a valley in the middle of which is a winding stream bordered by a meadow, with rolling foothills and forested uplands on either side. The foreground represents a lake and brook amid trees, with undercover of shrubs and woodland grasses on one side and drier upland country on the other. The Department's entire 18-unit exhibit has been installed in the United States Government building at the exposition.

National Park Service.—Secretary of the Interior HAROLD L. ICKES has placed on record his unalterable opposition, and that of his department, to any plan for damming Lake Yellowstone or in any other way diverting Yellowstone's streams and lakes to commercial use.

Several National Park Service officials attended the meeting of the National Conference on State Parks held at Bear Mountain in the Palisades Interstate Park, May 25, 26, and 27.

Director ALBRIGHT was presented with the 1933 Pugsley Gold Medal for his services as superintendent of Yellowstone National Park and as Director of National Parks. The awarding of gold, silver and bronze medals annually in recognition of outstanding public service in the establishment and development of national, state, county and municipal parks in the United States, was established in 1928 by Mr. CHESTER D. PUGSLEY of Peekskill, N. Y., in honor of his father, Hon. CORNELIUS AMORY PUGSLEY.

Director Albright reported on the emergency conservation work being carried on in the national parks, and Assistant Director H. C. BRYANT addressed the conference on the subject of trends in the educational program of the national parks.

Geologist EARL A. TRAGER and Senior Park Naturalist and Forester ANSEL F. HALL installed National Park Service exhibits at the Century of Progress exposition at Chicago.

Dr. CARL P. RUSSELL, Field Naturalist of the National Park Service, addressed the Chicago meeting of the American Association of Museums on June 14.

The Committee on Libraries in the National Parks of the American Library Association, headed by Mr. C. EDWARD GRAVES, has prepared a plan of development for national park libraries. This plan was presented to the Secretary of the Interior on April 12, and it is hoped that financial means for putting the plan into operation will be forthcoming in the near future.

Department of Terrestrial Magnetism.—J. W. GREEN attended the meetings of the Fifth Pacific Science Congress at Vancouver and Victoria, Canada, June 1 to 14, as a representative of the Carnegie Institution of Washington and the Department of Terrestrial Magnetism. At these meetings he presented six papers by members of the Department, all pertaining to terrestrial magnetism and electricity with special reference to the Pacific region. H. W. GRAHAM, also of the Department of Terrestrial Magnetism, who has been at the Hopkins Marine Station, Pacific Grove, California, studying biological material collected by the "Carnegie," also attended the meetings, where he presented five additional papers.

Dr. M. A. TUVE and O. H. GISH attended the meetings of the American Physical Society, American Meteorological Society, and the American As-

sociation for the Advancement of Science at Chicago, on June 19–24. On June 23, Dr. TUVE presented at the Nuclear Physics Symposium of Section B, of the American Association for the Advancement of Science and the American Physical Society, a paper on *Disintegration experiments on elements of medium atomic number.*

During the summer sessions at the Johns Hopkins University, a special series of lectures has been arranged by the Department of Chemistry on *Recent developments in chemistry.* In a group of these lectures on *Chemistry and physics in cancer* Dr. TUVE is to give a talk on the subject of *Supervoltage radiations.*

New Insecticidal Fumigant.—In view of the high toxic hazard of hydrocyanic acid gas to personnel in connection with fumigation, the Bureau of Medicine and Surgery, Navy Department, has recently conducted a study of carboxide gas as an insecticidal fumigant for bedbugs and cockroaches for application aboard naval vessels. Carboxide gas is a mixture by weight of 9 parts of carbon dioxide and 1 part of ethylene oxide, the carbon dioxide removing the fire hazard and practically doubling the toxicity of the associated ethylene oxide. Carboxide gas was found to be effective in comparatively small dosages such as to render it economically practicable for conveniently short periods of exposure. With ordinary care a gas mask is not required for fumigation with carboxide and expert personnel is unnecessary.

A detailed report of this study will appear in the July, 1933, number of the United States Naval Medical Bulletin under the caption *Carboxide gas: A new insecticidal fumigant for bedbugs and cockroaches,* by Captain E. W. BROWN, Medical Corps, United States Navy.

George Washington University School of Medicine.—The following new full-time appointments have been announced in the School of Medicine, George Washington University: EDWARD BRIGHT VEDDER, M.D., as Professor of Experimental Medicine and Executive Officer, Department of Pathology and Experimental Medicine; WILLIAM HENRY WALLER, Ph.D., as Instructor in Anatomy; JESSE HARMON, B.S., Ph.D., as Instructor in Biochemistry; HUBERT SCOTT LORING, B.S., Ph.D., as Instructor in Biochemistry; JAMES LESLIE SNYDER, B.S., M.D., as Instructor in Pathology; JOHN RALSTON PATE, A.B., M.D., as Teaching Fellow in Anatomy.

NEWS BRIEFS

Two new national-forest primitive areas have been set aside by the Forest Service. They are in the Shoshone National Forest in Wyoming, and will be known respectively as the North and the South Absaroka Primitive Areas.

Employees of the Federal Government who develop patentable inventions need not assign the patents thereon to the United States Government nor grant the Government exclusive rights to the use of the inventions, in cases where they were not specifically assigned to work out the inventions concerned, the Supreme Court recently ruled in the suit of the Government against the Dubilier Condenser Corporation. The opinion was concerned with three radio inventions brought forth by F. W. DUNMORE and P. D. LOWELL while they were employed at the Bureau of Standards, Department of Commerce.

Two new fungus allergens, *Alternaria*, found in atmospheric dust, and *Trychophyton*, a skin parasite, have been recognized by Dr. HARRY S. BERNTON, a Washington physician, and Dr. CHARLES THOM, of the U. S. Department of Agriculture.

Hurricane warnings issued by the U. S. Weather Bureau this year will have the advantage of news direct from the sea areas. Under a new plan worked out by E. B. CALVERT, chief of the forecast division, ships at sea in regions known or suspected to be generating hurricanes will receive radio requests for data, which will be incorporated into the announcements sent out by the Weather Bureau.

Men trained in forestry, entomology, plant pathology, biology, and other sciences applicable in forest work, not now employed, may be able to find positions in the supervisory personnel of the emergency reforestation "army," the Forest Service has announced.

"Heavy" water, containing high proportions of hydrogen isotope 2 and oxygen isotopes 17 and 18 has been prepared at the Bureau of Standards by distillation, depending on its higher boiling point. It has also been segregated from "common" water by adsorption on activated charcoal.

Surgeon General ROBERT U. PATTERSON informed the Conference of State and Provincial Health Authorities at their meeting in Washington that the health of the men in the conservation camps is above average, and that no cause for anxiety over possible epidemics need be entertained.

The grain-raising regions of the West will experience a plague of grasshoppers this year, a survey by the Bureau of Entomology, U. S. Department of Agriculture, indicates. The eggs left in the soil by last year's insects have survived the winter in almost perfect condition, and recent hot weather is bringing about a practically 100 per cent hatch. Some of the states where the grasshoppers will be most numerous have little or no money to spend on poison baits for holding them in check.

New Minimum Temperature Record.—The U. S. Weather Bureau has accepted as official a minimum temperature of $-66°$ F., observed February 9, 1933, at the Riverside ranger station in Yellowstone National Park; one of several stations in the park at which meteorological observations are made under the supervision of the Weather Bureau. This is the lowest temperature hitherto officially recorded in the United States; the previous extreme having been $-65°$ F. at Fort Keogh, near Miles City, Montana, registered January 13, 1888.

From the report of this observation it appears that the temperature may actually have fallen below the value given above, as the index of the official thermometer was found as low as it would go, while an unofficial instrument in the immediate vicinity, constructed to register lower readings, showed a minimum temperature of $-69°$ F. on the same day. A subsequent comparison of the official and unofficial thermometers, at higher temperatures, showed them in substantial agreement.

Submarine Deep and Peak.—The Navy Hydrographic Office received from the U.S.S."Ramapo" a radio report of a sonic sounding taken April 30, 1933, of 5501 fathoms in the southern end of the Tuscarora Deep about 250 miles southwest of Yokahama. The application in the Hydrographic Office of correction factors for sonic soundings from data obtained in this vicinity by the

ship "Carnegie" of the Carnegie Institution resulted in a corrected depth of 5,770 fathoms. This sounding is 611 fathoms greater than the greatest depth obtained in the Tuscarora Deep by the Japanese surveying ship "Manchu" in 1924, and ranks the new found deep as second only to the depth of 5,900 fathoms found by the German Cruiser "Emden" in the Mindanao Deep in 1927.

A submarine peak, jutting upward from water more than a thousand fathoms deep, was discovered on the night of May 4 by the U.S.S. "Patoka," Commander Ralph B. Horner. Fathometer soundings indicated only 11 to 15 fathoms. The position of the "Patoka" at the time of shallowest soundings was latitude 49:25 north, longitude 129:20 west. This position is about 200 miles west north west of Cape Flattery, and 65 miles off Cape Cook, Vancouver Island.

Personal Items

Dr. Lyman J. Briggs was confirmed as director of the National Bureau of Standards by the Senate during the last days of the special session.

Dr. David Fairchild, veteran plant explorer of the U. S. Department of Agriculture, has been designated as the recipient of the Public Welfare Medal of the National Academy of Sciences. The presentation will be made at the next annual meeting of the Academy.

Dr. F. B. LaForge and Dr. H. L. J. Haller of the U. S. Department of Agriculture have been awarded the Hillebrand Prize of the Chemical Society of Washington, in recognition of their researches on the chemical structure of rotenone.

Watson Davis has been elected Director of Science Service, succeeding the late Dr. Edwin E. Slosson. Since Dr. Slosson's death in 1929 the directorship has been vacant.

Meeting in Paris recently, the Permanent Committee of the International Veterinary Congresses elected Dr. John R. Mohler, chief, Bureau of Animal Industry, U. S. Department of Agriculture, vice president, to succeed Dr. Emmanuel Leclainche, chief of the Government Veterinary Services in Paris. Dr. Mohler will take an active part in the 12th International Veterinary Congress, to be held in New York City, August 15–19, 1934.

Dr. William A. White, superintendent of St. Elizabeth's Hospital, was re-elected president of the District Social Hygiene Society at a recent meeting of the Society's board of directors.

Mr. Edward J. Phelan, Chief of the Diplomatic Division of the International Labor Office, spoke on *The International Labor Organization and the World Economic Conference,* at the Brookings Institution Residence, on Tuesday, May 16.

Medical Director Edward Francis of the U. S. Public Health Service was awarded the degree Doctor of Science, *honoris causa,* by Ohio State University on June 23.

Surgeon Charles Armstrong of the U. S. Public Health Service was awarded the degeee Doctor of Science, *honoris causa,* by Mt. Union College on June 6.

At the annual Medal Day exercises of the Franklin Institute in Philadelphia on May 17, Dr. D. J. McAdam, Jr., chief of the optical metallurgy section of the Bureau of Standards, received the Edward Longstreth medal.

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This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors before the tenth of one month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following month.

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ETHNOLOGY.—*French survival in Canada.*[1] Marius Barbeau, National Museum of Canada. (Communicated by N. H. Heck.)

We are so immersed in the stream of modern life that there is not enough time for retrospective or casual wanderings in the byways of our continent. Yet certain things there at times hit us in the face as it were, and we take notice with surprise, though they are by no means novel in themselves. For instance, French survivals in Louisiana and Quebec.

We remember from reading that America was different from itself once not so long ago—only a hundred years back. But somehow we do not quite feel it in our blood. It matters little whether the Mississippi and the Saint Lawrence first were French, indeed so remained effectively until the beginning of the last century; whether the Southwest was Spanish-Mexican as far north as Colorado—to its very names; whether Alaska was under Russian domination for two hundred years until 1880; or whether survivals from the colonial period still dot our map with patches of odd colour and jar with our sense of standardization and straightlaced uniformity.

To be honest we enjoy getting out of our accustomed environment, in the summer holidays and seeing things that strike us as different and refreshing; odd people with peculiar ways and looks, a vernacular tantalizing the ear, houses and buildings redolent of Normandy or Spain; or churches, priests and nuns that smack of Rome and look like the personnel off the stage of grand opera houses which we patronize in the winter.

The lack of familiarity with those old-time features is what removes them from our sphere; they are as if inexistent until they have become real experience. But a little imaginary jaunt with me to one spot in Quebec may take the place of this and convey an impression of ac-

[1] Address delivered before the Academy January 12, 1933. Received April 6, 1933.

tuality. I hope it will. I said, one spot. That is enough, for we can sample there interesting bits that fairly represent the whole. And Sainte-Famille (the parish of the Holy Family) is our choice, on the Island of Orléans, twenty miles northeast of Quebec City.

More exactly, we stand in front of the parish church in one of the oldest French settlements in the Saint Lawrence.

The serenity of this Laurentian scene facing the north is like a magic spell. It is as if the small village we have entered were asleep in the sunlight, like the princess in the folk tale awaiting a kiss to waken. No one moves in the landscape. The lawn in front of the church is empty; so is the road that runs east and west. Sainte-Famille is not really a village, in spite of its cluster of houses. It is a rural community that toils the whole week in the gardens and the fields and becomes a social body only once a week, on Sunday, when the church bells toll their call, and the parishioners gather in their best clothes for prayer and gossip.

The stone church, whitewashed outside, sits sideways to the road and faces the west, as all Quebec churches do. Why the west, I have never learnt. Perhaps a lost symbol. Lombard poplars stand alongside like pious attendants holding candle-sticks within the graveyard wall that surrounds the nave, the transept and the choir to the rear. On the high gable five saints, carved out of wood and weather-beaten, stand in as many niches well spaced out between doors and arched windows. Two massive towers rise on each side, and their graceful belfries beside the higher central spire crown this royal front and glitter in the midday light. One feels like speaking in whispers here, out of reverence for something unseen but felt—and eluding full comprehension.

Two substantial stone houses, also whitewashed, with French mansards, face us one nearer than the other. They are surrounded by lovely orchards covering the whole slope below the church that leads gently all the way down to a fringe of tall trees, and then, unseen, leap the cliffs two or three hundred feet high on to the bottom lands of the tide-waters.

Beyond this opens up a wide vista, the north arm of the river and beyond, the Laurentians, miles away. The greenish river runs either way with the tide.

This is dreamland scenery in a way, not for its quiescent splendor alone, but because it invites to contemplation and draws out one's thoughts one by one.

There, on the low prairies close to shore, the old villages of the Beaupré Coast stretch out lengthwise like a rosary along the "King's road." The farms run up and down like green ribbons, quite narrow, from the river up to the wooded hilltops in the mellow blueish distance.

Within the compass of the eye we have a synopsis of the whole of French Canada and scattered hints of its romantic past.

Here Cartier, the discoverer of the Saint-Lawrence, in 1535, paused in his journey up the river, and wrote in his memoirs:

> "We found the island covered with very fine trees, such as oaks, elms, pines, cedars and others and also plenty of wild grapes which we saw whereever we set foot. For this reason we named it Island of Bacchus. It is about twelve leagues long and consists of very fine level land, mostly wooded, without ploughed fields. We found there small huts occupied by Indians while they fished . . ."

But he called it Ile d'Orléans, after the duke of that name, in the spring of 1536.

Champlain, the founder of New France, seventy-three years later (1608), also described the island in his memoirs, like this:

> "It is rich with woods of all sorts, such as we know in France; it is very fine and edged with natural prairies on the north side that are flooded twice a day. There are streams and springs, and a store of wild grapes in many places. . . . The coast has a number of brooks that abound with fish. Game of various kinds is also found there in incredible abundance, as on the prairies of Cap-Tourmente (opposite), a splendid place and a pleasure to the eye . . ."

The island and the shore opposite soon after the discovery were ceded as a *seigneurie*, that is, they became a seignorial estate. The nobleman into whose right it passed landed there with the Governor, and took possession of it according to feudal usage: broke a few branches, pulled out shrubs, flourished an empty pistol at a grouse or a rabbit, and walked around like a lord, with picked escorts, on his feudal domains.

The brand new *seigneur* did not further avail himself of his rights but ceded them to the first bishop of Quebec, Mgr. de Laval, who later exchanged them for others with Berthelot, an influential man at the Court of France.

These facts, trivial in themselves, will show how the seignorial system of land tenure was established and the country was first opened to colonization.

Mgr. de Laval, for several years owner of the island after 1662, brought a number of settlers there from northwestern France and planted them upon his estate. Most of them were of Norman extrac-

tion; others came from the Loire River provinces. The population of the island, in 1667, was 529, whereas that of the town of Quebec was only 448, out of a total of 4312 for the whole of Canada.

When Berthelot acquired the bishop's rights thirteen years later, a full-fledged seignorial estate already existed on the island, with farms, buildings, forest preserves, dues from tenants—*rentes seigneuriales*—and wind-mills. The new seigneur improved his domain for some years, till the population in 1681 reached the substantial figure of 1080.

The island settlement then was practically complete, insofar as heads of families and basic traditions are concerned. The map made a few years later (1689) by the French engineer Villeneuve—one of the earliest of the kind in America—shows the parishes, the farms and the names of the owners, much as they are to-day.

Used as we are on this side of the Atlantic to think of a hundred years in retrospective as a long way off, we now have to attune ourselves to an older environment. People were already toiling here, at this very spot, over two hundred and fifty years ago—much the same by name and custom as to-day. To realize this in itself is a new experience. The parishioners of Sainte-Famille at that time were building stone houses and log barns. Their first church or chapel stood there to the right, on the slope, a few hundred feet below the present. It was of timbers (*colombage*) and the hipped roof was thatched—rather small and rustic for a church, but the facilities were most limited; everything had to be fashioned on the spot, so far away from the motherland. It is not everywhere that panes of glass were available for windows just then; oiled skins were used instead.

But what would seem hardships to us was wholesome like brown bread to those early pioneers, who do not seem once to have regretted their choice of a new abode in the new world. They were here to stay, no matter what happened; and their settlement at once shot vigorous roots into the rich soil.

Should you doubt it, we can make sure of it this very moment. Come along to the *presbytère*, the *curé's* house in front of us two hundred feet from the road down towards the river. The presbytère itself in part is an ancient house, nearly 250 years old. M. Martel, the parish priest, is there ready to receive us with a Norman smile, his eyes inquisitive, yet half closed, slit-wise. A good name his, quite French, and old as France itself. Charles Martel, the first of that name, was king of France, back in the centuries before the year one thousand, who defeated the Moors when they invaded central France.

Out of the stone vault M. Martel will produce the first parish registers, under motley parchment covers. You could not read the writing, fine though it is. Its style is Gothic, as in the old medieval scripts. But I have grown used to it.

Here you can see the names of the people back in 1675, 1700, as they were married, baptized or buried; Gagnon, Blouin, Morency, Dion. . . . These are the very names of the farmers around here; plus many others.

Take the name of Gagnon, for instance. A familiar one in French Canada; there are hundreds of Gagnons in North America, I should say thousands! Well, one of their two roots is still in the ground around here; the other is on the shore opposite. Their first ancestor Robert, from Perche, France, settled here in 1657. A monument along the road near here, a wayside shrine, commemorates his coming, and a bronze tablet holds up the information: erected in 1909 in honour of Robert Gagnon, the first settler on this farm, by 41 priests of his name, living and grateful! There had been to date 62 priests of this family, 53 of whom were still living. This happened nine or ten generations after the first Gagnon had begun to toil here with the spade and the hoe. And his record is just like many others alongside.

That will do for old musty records!

There is a smell of old wall-paper, tapestries, plaster or lime—a fragrance of centuries and sedate respectability—in these old houses that gets at you from the first moment. It makes you feel that many people before us have come and gone, some of them in queer garments, different from ours, with a still queerer mind—people who knew nothing of steam or electricity, who counted money in *Livres*, and believed the King of France the eldest son of the church in Christendom.

If we step out on to the porch we can see, a few hundred feet below, one of the oldest convents in America. Yes, still the same walls though they have been raised and restored more than once; and the roof was changed. There the nuns still keep the table and chair of the venerable founder of their order, Sœur Bourjeoys. Date, 1701.

So education entered the island alongside of the pursuits of rural life.

Soon after the settlers had faced the forest and challenged it with axes and whip-saws, they seem to have forgotten their own kinsmen in provincial France. Little, if any, correspondence passed the ocean between them; still less could there be any notion of mutual visits. The past was as if buried, except insofar as it subsisted in the present.

Sailing ships were few, casual and erratic. Two years once passed,

about 1705, without any contact with the motherland. The war with England was to blame. The bishop of Quebec was made a prisoner on the seas, and valuable cargoes were confiscated. So everyone had to shift for himself.

The *habitants* wove their own homespuns, flannels and linens—just as today. They made their shoes—*bottes sauvages,* which they used most of the year. Yet on Sundays they, particularly the young women, wanted to have smart French shoes—*souliers français.* They wore their home-made shoes most of the way to church when the paths were muddy, and then stopped and changed their footwear. From there they would strut precariously on high heels! For rare events they managed to ape the style of the higher class, but usually they looked just like plain peasants; and they were none the worse for it. For they were hardy, self-reliant and sufficient. One wonders at times whether their government with its political intrigues was not just a nuisance to them.

The sailors often met with storms on the high seas. When it happened they fell down upon their knees and made vows to Sainte Anne. This was done according to an immemorial custom. Many shrines on the coast of France bear this out. One was erected by seamen on the Beaupré coast, there, almost in front of us, on the opposite shore. We can see the little town in the distance—Sainte-Anne de Beaupré.

There is such a widespread belief in miracles and occult cures, that pilgrims and tourists from far and wide gather here in large numbers every summer, some of them hoping for sadly needed miracles.

The favours of Sainte Anne at first were mostly confined to sea folk; this is shown by old painted canvases, in the Memorial church, which represent sailors praying at sea while the storm lashed them. But they now cover the whole range of human vicissitudes. The growth of Sainte-Anne as a pilgrimage center is an interesting story.

From a chance stopping place, it became a pilgrimage and trade center during the French period. The Micmac Indians from the maritimes used to come on yearly visits to the shrine. While there they disposed of their furs, were banqueted, and managed to leave more than they received. But they went away satisfied.

The parishioners of the Beaupré Coast also were fond of going to the shrine overland, miles away; those of Ile d'Orléans likewise; they crossed the river in their sail boats. This happened once a year, in July or August, for the feast of Sainte Anne. A pious pilgrimage, yes. But the people so seldom in their lives went away from their home

Fig. 1.—Quatrième Rang, in the Laurentians, from a painting by Gordon Pfeiffer, Quebec, 1932.

Fig. 2.—An Acadian interior, at the Louisbourg Museum, Nova Scotia.

Fig. 3.—Patry, an old wood carver, his tools, and old Quebec wood carvings.

Fig. 4.—Weavers at their loom. Homespun and hooked rug.
First Quebec Festival, 1927.

that they were apt to treat this as a feast, and there are always some black sheep in the herd! Men would procure spirits and get riotous. Another abuse was that of young men and their fiancées travelling in carts from distant parishes on the coast and stopping overnight on their way. And the good shepherds wondered at the spiritual gains and losses of their flock in the end.

But Sainte-Anne as a pilgrimage center thrived nonetheless, like those of France and Spain. The church there is perhaps the largest in Canada. It is patronized mostly by strangers from afar. The *ex votos* and crutches stacked up around the pillars of the church make an impressive display for the tourists, protestant like catholic, who come there in vast numbers every summer.

Whatever we might see, if we continued our imaginary jaunt farther into the Laurentians, would tell the same tale; one of pioneering, of gradual changes and growth. For there was growth here, not merely survival. Survival is a thing of the past, unchanged and negligible as it were, or if changed, for the worse. It flavours of decay and may soon drop off the walk of life.

Not so with the people here or the manifestations of their existence. They are alive and sturdy. So they have been for two or three centuries. The depression does not hit them hard, because they have weathered many others, and are self-reliant. They own fields, gardens, cows, sheep and orchards. And there are many things they can do, for their hands are trained for many home crafts. As a people they have not merely survived, but they have multiplied, expanded. From French folk, they have become thorough Canadians, and since the day of their landing here they have gone on adapting themselves to changing surroundings. And no one in America is more attached to his homeland—for him the best under the sun.

Surprise is often expressed at the survival of so many historic features in Canada, indeed at the survival of the French language itself. Nearly 200 years have passed since the Fall of Quebec (1759), and over 250 years since the original settlements were practically complete. At an early date, the stream of emigrants to the New World was growing in size. Many were they who did not resist the lure of freedom and adventure. France, like Spain, might have lost its lifeblood to its colony had not Louis XIII, by his edict of 1673, stemmed the ebbing flow of his rural population. Nine thousand people from Normandy and the Loire River by that time had established their homes in the woodlands of New France. It is from this seventeenth century nucleus—which has doubled in size every thirty years since—that are

descended the three million French-Canadians now living in the Saint Lawrence watershed.

From the mere fact of the survival of their culture, outsiders may conclude that French-Canadians are refractory to assimilation, that they are not adaptable. But this assumption is hardly justified.

Many of them in the past have left their province never to return; they may be found everywhere from Labrador to California. They migrated in bulk to the United States, more particularly to the manufacturing centers of New England, in the economic crisis of the eighties. Since, they have been largely absorbed by new collectivities, though their numbers there have reached a million.

A French-Canadian loves an adventure and a change of surroundings, like the ancient *coureurs-des-bois*. Language is no barrier. He soon learns another. He is adaptable.

But the process of assimilation is slower when he associates with his compatriots in compact clusters—and he would rather live with them. But there is fairly little left of the old ways and customs in the scattered French settlements of Michigan, Wisconsin, the Prairies and Oregon.

Some of those settlements go back to colonial times. One of them—Louisiana—is of considerable size; it took new proportions with the coming of the Acadians, after their deportation, in 1755. Yet it is losing its individuality like the others. The language struggles hard to hold its own, but it is not everywhere passing to the new generation. And the language is the last rampart of nationality. Within Canada likewise, the Detroit River colony—a substantial one—is now mostly English-speaking, and the Acadian groups of the Maritimes have gone a long way towards assimilation.

All in all, French-Canadians have become Americans or English-speaking in the proportion, roughly, of one to three. And the process is more than ever at work.

The major group of Quebec alone—well over two million French-Canadians, speaking their native language, Catholic, and aware of their nationality—has stayed the forces at work for its disintegration.

French-Canadians remained in majority on the Saint Lawrence for over a century after the fall of New France, in 1759. They were eighty thousand to a few hundred British, a score of years after the Conquest. Sturdy and self-supporting, they absorbed many of the immigrants of other countries. The Scotch intermarried with them, at Murray Bay, Fraserville (Rivière-du-Loup) and in the Eastern Townships, and lost their nationality.

The Meuron and Darmstadt regiments of the British army in the American war were disbanded in Quebec, and were assimilated. After the Napoleonic wars, some British soldiers received grants of land at Sorel and in Gaspé. Shiploads of Irish immigrants landed along the Saint Lawrence after 1830. Many of them have since become French-Canadians, with only their name for a token of a different origin.

The British settlers, for the sake of self-preservation, on the whole preferred other parts of Canada—Ontario and the Maritimes. An upheaval, after 1830, brought them into closer association with French-Canadians, who likewise were in the throes of political agitation. The secession of Canada, for causes not unlike that of the American colonies, might have resulted, but for the suppression of the Quebec Rebellion in 1837 by British troops. The Upper and Lower Canadas formed a Union Government in 1840, as soon as they secured the rights they were agitating for. But it is only after the British element was in majority that Confederation as it now exists was established, in 1867.

The tables have turned. Quebec now is a minority within Canada. And it is fast becoming part of the American economic system. In mere numbers it amounts to less than three to well over a hundred millions. It cannot help but swim with the stream.

The survival of French Quebec to this day is not due only to its aloofness and long-continued isolation. It rests chiefly on its vitality as sustained by a wealth of ancestral traditions.

New France was in the hands of monopolies for the benefit of the fur trade. The early colonists endured severe trials for over a hundred years. They were like pawns in the rivalry of France and England. Indian raiders several times invaded their homes at night and massacred them. The Richelieu for that reason was called "Blood River," as it was the highway to New England and the country of the Iroquois. It is only after 1705 that homespuns could be made for domestic use, for this would have been an infringement upon the privileges of the monopolies. An attempt to manufacture felt at Lauzon, opposite Quebec, was suppressed and the tools were destroyed. But the capture by the British of *La Seine*, a French ship with goods for the colonists, brought about greater tolerance. Madame de Repentigny revived the textile industry. The settlers began to cultivate flax and raise sheep; they made spinning-wheels and looms, and provided themselves with flannels and linen. It is at that date that the handicraft of weaving was established in New France. It survived everywhere till after 1880, when manufactured goods were introduced on

a large scale. The country folk would buy, who had nothing to sell. Soon empoverished they began to migrate on a large scale to New England. Homespun since has been made extensively only in a few of the oldest districts—Quebec, Montmorency and Charlevoix.

Handicrafts and trades were transplanted to the New World at an early date, from sheer necessity. Without craftsmen the colony could not be self-supporting. The pioneers, if they built their own houses, could not erect large buildings, churches, manors and fortifications, for the lack of expert knowledge. The church of Ste. Famille, from the hands of unaided ploughmen, cracked from top to bottom and had to be taken down in less than fifty years.

Intendant Talon and the first bishop of Quebec, Mgr. de Laval, more than their predecessors realized that New France must be established on a firm basis—apart from the fur trade. After the land was cleared and scattered settlements dotted the shores of the Saint Lawrence, they decided to make the colony self-supporting. This they achieved to a remarkable degree, in the years that followed 1660. Masters and craftsmen were brought over in sufficient numbers. Schools, convents, hospitals, and the Seminary of Quebec, were founded. All of them, with the exception of the Jesuit College, which was abolished at the Conquest, have endured to this day.

The settlers, besides, brought over with them a vast hoard of traditions. They had left their province before the diffusion of printed books. The spoken word, rather than writing, served in the transmission of ancestral wisdom and knowledge. And the traditions of France in the period that immediately followed the Gothic were unsurpassed in wealth. The emigrants as they journeyed across the sea brought over with them an ample heritage. They found solace in their memories and conserved them intact in the solitudes of their new woodland homes. To these traditions no less than to their domestic handicrafts the French-Canadian *habitant* owes his survival.

The echoes of the canoe songs preceded the French explorers and the *coureurs-des-bois* wherever they ventured in the American wilderness. La Rochefoucault, a Frenchman visiting the West early in the nineteenth century, says,

> "We were led by Canadians who, as is their wont, never ceased singing for a moment. Their songs are gay, often a trifle more than gay. They are at times interrupted by the laughter they bring forth. In all the canoe journeys undertaken by the Canadians, songs follow the paddle, beginning as soon as it is picked up and ending only when it is dropped. One has the pleasant illusion of being in provincial France."

A French diplomat, Duflos de Mofras, had a similar experience much later, in the remote regions of Oregon, in 1844:

"Oftentimes, in our canoe journeys along the Columbia River, our heart quickened when our oarsmen, even in the rain and the wind, enlivened those lonely shores with their chants so reminiscent of ancient France."

Thomas Moore, the Irish poet, was escorted by Canadian canoemen down the Saint Lawrence, from Kingston to Montreal, in 1803. He wrote in his memoirs:

"Our voyageurs had good voices and sang perfectly in tune together. . . . I remember when we have entered, at sunset, upon one of those beautiful lakes into which the river so grandly and unexpectedly opens, I have heard their simple songs with a pleasure which the finest compositions of the first masters have never given me." . . .

Folk songs, more than any other form of popular art, until recently were part of the mental equipment of uneducated French-Canadians. There were songs applying to almost every phase of daily life. Children, lovers, mothers, workers, drinkers, all had their songs. People were less morose and more musical in the old days. A singer with a fair memory possessed a large assortment of all kinds of carols and tunes. There is nothing abnormal in the memory of two of our best singers—Saint-Laurent and de Repentigny—who recently gave us over 300 songs each, mostly learnt in childhood. And the collections which I have made with the collaboration of a few friends for the National Museum of Canada, in the past fifteen years, are only a part of an elusive total still beyond our appreciation. The sheer force of survival in this domain is well illustrated in the drinking and love songs. Hundreds of these songs, for planting vines, for harvesting grapes or the merriment of wine drinkers, are still remembered by the *habitants* who have no actual knowledge of these things in their northern climate. If license is seldom heard of in rural life, countless love songs glorify the genial irresponsibilities of Arcadia.

Most villagers often have enjoyed folk tales like those of the Dragon with Seven Heads, Blue-beard and Jack the Giant Killer. Handed down in large numbers from the past, they were in full bloom not so long ago. New anecdotes about the werewolf, the *chasse-gallery* or changelings, dwarfs keeping buried treasures, wandering souls from the nether world, sprang every day into existence. Rumours of marvelous events often stirred the curiosity of the least credulous.

Should these traditions pass to the new generations, there is no doubt but that the flavour of the old Gallic spirit would survive among them. They are a font of youth and serenity, at the core of

the naive feeling that no place under the sun is as good as the farm where eight or nine generations of ancestors have thrived. But these things have come to the end of their long journey. Rural life has been robbed of its privacy and self-confidence. It has withered up under the dust of automobiles. Folk singers are dying out.

Traditions were not exclusively the *apanage* of country folk; they were not all transmitted merely by the spoken word. Some of them belonged to the schools, of which there were not a few in Quebec, Montreal, Three Rivers, and in some of the country places.

The clergy, the religious orders and the nuns, as in all latin countries, were an important element. Though recruited from the people, they were like a class by themselves. Writing and book learning were their privilege, no less than ministering to the needs of the people and evangelizing the Indians. Their activities often reached into broader fields, as in the instances of the Seminary of Quebec, the Ursulines and the nuns of the Hospital General.

The Ursulines, whose foundation goes back to the first decades of Quebec, educated Indian girls from the northeastern tribes—Eskimo, Algonkin and Iroquois. They trained them in the handicrafts likely to be useful to them in life, such as sewing and needle work. It is there, at that time, that originated the floral designs in the Renaissance style which now characterize the bead and silk work of our modern North American Indians. Fine embroidery as a tradition was conserved chiefly by the Ursulines, although other communities shared with them the profitable business of providing the churches with embroidered garments for worship.

The nuns of the Hospital General were professional gilders in addition to their other activities. The wood carvings that were made for the sanctuaries—altars, reredos, statues and candle-holders—were gilded in their shops. They kept the secret of their processes (in France it was the privilege of a regular guild) to themselves, a secret shared at a later date by the Ursulines and perhaps also the Quevillon school of woodcraft. The cost of gilding an altar exceeded that of its carving.

The School of Arts at Cap-Tourmente and the Seminary of Quebec was of still greater importance. Mgr. de Laval founded it in 1672, after he had secured support at the Court of France of some noblemen, as fine arts at the time were considered no less essential for the decoration of churches than crafts were in the ordinary walks of life. He engaged some of the best wood carvers of the day, one of them—Leblond de Latour—from Bordeaux, and over thirty masters

in other handicrafts. The students in the Seminary learned carving no less than letters and theology. A few altars and statues from their hands are still preserved in the churches of the Beaupré coast. This school seems to have gone out of existence, except for agriculture, about 1715, after the death of its founder and supporter. But it has left its mark on the professional handicrafts of the country.

Many useful arts were otherwise transplanted into New France late in the seventeenth century, with the arrival of silversmiths, architects and unattached wood carvers, joiners, masons, potters, tapestry-makers. The census for 1744 holds a list of no less than sixty distinct handicrafts that were practised in the town of Quebec alone.

Architecture at the time of the Conquest had already gone through two distinct periods since the beginning, that of the de Laval masters, whose style was of the early Renaissance—or the Bourguignon School—and of their successors at large whose art followed the times: de Léry, a nobleman and engineer, the LeVasseurs and the Labrosses, hereditary woodcarvers, and several others.

Two independent schools of carving and colonial architecture came into existence after the Conquest, with the growth of the population, one of them in Quebec, and the other near Montreal, at Ile-Jésus. The first, that of the Baillairgés, continued the traditions of the early Renaissance while evolving a type of naturistic floral decoration that was indigenous. The other, of Quevillon, adopted the rococo of the Louis XV period. The ancient school quarrel of the classic *vs* the rococo was revived between them, after 1800, as a result of their rivalry in practically the same field. A few amusing episodes are to be found in the parish records of that date.

Wood-carving was indeed practised on a large scale from 1780 to 1850 or even later, for church decoration and domestic furniture. It formed the largest industry of the time, and reached a high point of excellence. What is left of the carver's work, and there is much of it—as well as silver work by Ranvoyzé and Amyot, enables us to judge of their high standards as well as individual achievements.

This art survived in Canada long after it had given way to other styles in other countries—to the Georgian, the Neo-classic or the Neo-Gothic. But it was enough that two Sulpicians of Montreal should go to New York, in 1825, and see a Gothic church built by James O'Donnell, an Irish architect trained in London, to kill this Canadian tradition. The priests admired the New York temple so much that they engaged its architect to build one like it for them at home. O'Donnell met with such difficulties in bending his rebellious

workmen to his own ways—Gothic was new to them—, that he died from exhaustion, but not before he had become a Catholic. He was buried in his church before it was finished.

When the vast structure stood complete at the Place d'Armes, the people considered it a marvel. It was so big and novel! Gothic henceforth was the style in vogue throughout Quebec. The French Renaissance had fallen into disfavour. It is now a thing of the past.

Traditional arts likewise have given way to novelty, not for the best. Quebec is becoming industrialized. Houses formerly were built of stone or heavy logs; their roofs were hipped in the Norman fashion. They are being razed to the ground, because American cottages are preferred, or plain slum match-boxes.

Oral and manual traditions no longer are the staying power of the race. French Canada is fast losing its characteristics. Survival in the past is not criterion for the future. Conditions now are different. The spirit of conservation is broken. The world is on the move.

BIOCHEMISTRY.—*Studies in cancer: the application of the Rupp-Schied-Thiel thiocyanate reaction to the urine.*[1] M. X. SULLIVAN and W. C. HESS, Georgetown University.

Among the projects of the Chemo-Medical Research Institute of Georgetown University is one aimed at the development of chemical tests on the urine which might be of value in the differentiation of cancer from other pathological conditions and from the normal. In surveying the work of others along this line attention was directed to the work of Saxl[2] who concluded that quantitatively thiocyanate is increased in the urine in cancer with values appreciably higher than for normals and higher than found in any other disease. He applied to the urine the very accurate iodometric method for thiocyanate devised by Rupp and Schied[3] and improved by Thiel.[4]

The reaction as applied to urine proceeds in the following way: An aliquot of urine, generally 50 cc., is made acid by addition of 5 to 10 cc. of 1 per cent nitric acid; the thiocyanate ($-CNS$) is then precipitated as the silver salt by the addition of silver nitrate (25 per cent solution) added dropwise with stirring, in slight excess. The mixture

[1] This work was supported by a Research Grant from the Chemical Foundation. Received May 17, 1933.

[2] SAXL, P. Biochem, Z. 55: 224. 1913.

[3] RUPP, E. and SCHIED, A. Ber. Chem. Ges. 35: 2191. 1902.

[4] THIEL, A. Ber. Chem. Ges. 35: 2766. 1902.

is centrifuged and the precipitate washed by stirring with 10 cc. of 1 per cent nitric acid and centrifuging. The precipitate is then washed into a liter flask containing 100 cc. of water, 3 grams of sodium bicarbonate, and 3 grams of potassium iodide. By stirring, any silver chloride present is converted to iodide to prevent reaction with the standard iodine next added. Then 5 to 10 cc. of 0.1 N iodine solution are added with gentle shaking. The brown solution is set aside for 4 hours preferably in a dark place to complete the reaction between thiocyanate and iodine. Then the mixture is carefully acidified with 10 per cent hydrochloric acid. Starch solution is next added and the whole titrated with 0.1 N sodium thiosulfate until colorless. The difference between the amount of 0.1 N iodine added and the amount left as shown by the thiosulfate titration gives the iodine reacting with thiocyanate.

The entire process covering the relation of thiocyanate to iodine can be expressed as follows:

$$KCNS + 3I_2 + 4H_2O = H_2SO_4 + 5HI + KI + HCN$$

As under the conditions one molecule of thiocyanate corresponds to six atoms of iodine, multiplying the cubic centimeters of 0.1 N iodine reacting by the factor 0.9846 gives the quantity of thiocyanic acid (HCNS) in milligrams in the aliquot of urine used. This procedure with a pure solution of potassium thiocyanate of known strength gives results with an error of less than 1 per cent.

In a trial experiment the Rupp-Schied-Thiel method was applied to the urine of (a) a patient with extensive abdominal cancer, (b) a patient with a small localized cancer of the jaw, and (c) three normals. The marked cancer case showed 164 mg. of HCNS in 515 cc. 24 hour urine; the mild case showed 95 mg. in 605 cc.; the normals gave an average of 100 mg. for an average volume of 986 cc. All these urines were collected over chloroform as a preservative. This preliminary study suggested that the comparative study of the apparent thiocyanate excretion in cancer as compared to other pathological conditions would be worth while irrespective of whether the Rupp-Schied-Thiel procedure when applied to urine is estimating a single substance or a medley of similarly reacting substances.

Shortening time of reaction.—The Rupp-Schied-Thiel reaction as ordinarily run calls for 4 hours contact of iodine with the washed silver precipitate. To hasten the study attempts were made to shorten this time. After some experimentation it was found that keeping the silver precipitate-alkaline-iodine mixture in a stoppered flask at

50° C. for 30 minutes gave the same results as 4 hours at room temperature.

With this modification, urinary thiocyanate was determined in fifteen cases of cancer, stomach, uterus, liver, prostate, etc., in comparison with twenty-one non-cancerous hospital cases with a wide variety of pathological conditions, and with four normals. The variation and average thiocyanic acid content of the 24 hour urine of the respective groups are: normal 67 to 140 mg., average 102.5 mg.; non cancer 56 to 273 mg., average 132.2 mg.; cancer 31 to 495 mg., average 155 mg. Fourteen of the twenty-one non-cancer hospital cases gave thiocyanate values in the normal range or below normal, ten of the fifteen cancer urines gave values in the normal range or below normal. As found by Saxl, the average thiocyanate content of the urine is somewhat higher than for other pathological conditions tested and much higher than for normal. In some cases, as for example, multiple myeloma, the apparent thiocyanate is exceedingly high. On the other hand, two-thirds of the cancer cases tested were within normal limits or below normal. The comparison of various cancerous conditions with other pathological conditions support the earlier conclusion of Sullivan and Hess,[5] on less extensive study, that the excretion of material behaving like thiocyanate in the Rupp-Schied-Thiel iodometric procedure applied directly to urine is not necessarily increased in cancer.

In some of the cases where the apparent thiocyanate is much higher than was found for other pathological conditions, preliminary experiments indicated the presence of other compounds than thiocyanate which will precipitate with silver nitrate and react with iodine in an alkaline medium. The second phase of the question is being studied.

[5] Sullivan, M. X., and Hess, W. C. Proc. Soc. Exp. Biol. and Med. **30**: 804. 1933.

PALEONTOLOGY.—*Pharyngeal plates of* Phyllodus *from the Virginia Eocene.*[1]

Benjamin Gildersleeve, Johns Hopkins University. (Communicated by E. W. Berry.)

INTRODUCTION

The specimens described in this paper were collected by Dr. W. G. Lynn of The Johns Hopkins University from the Aquia formation (lower Eocene) at Belvedere Beach, Virginia. Belvedere Beach is in King George County, 13 miles north-east of Fredericksburg, on the south bank of the Potomac.

[1] Received Feb. 7, 1933.

This remarkable genus was first described by Agassiz[2] and is known only by the pharyngeal dentition.[3] Over thirty species of *Phyllodus* have been described in the literature as occurring principally in Eocene and Miocene strata. Nicholson and Lydekker[4] make passing reference to its occurrence in the Cretaceous of Germany. Woodward,[3] however, says that the so-called *P. cretaceus* of Reuss from the Upper Cretaceous of Bohemia as well as *P. umbonatus* Münster and *P. depressus* Münster from the Miocene of Vienna are based on generically undetermined teeth which are probably not referable to the Labridae. According to Eastman[3] the genus is known in the American Tertiary only by the four detached plates described by Wyman[3] and Marsh.[5] The specimens which formed the basis for Agassiz's determination of the genus *Phyllodus* were found in the London clay or Sheppey.[6]

In 1850 Wyman[7] recorded for the first time the finding of this genus in the United States. The plates described by Wyman were collected by Dr. Martin Burton near Richmond, Virginia from the Tertiary, but he was unable to say whether they came from the Eocene or Miocene beds. Of the two specimens figured, the more perfect was identified as *P. toliapicus* Agassiz, and the other undetermined. Marsh[8] was evidently unaware of this find, for in 1870 he described the first discovery of *Phyllodus* in this country as being *P. elegans* and *P. curvidens*, from the Eocene and Miocene respectively of New Jersey. Neither of these species were figured by Marsh, although of his *P. elegans* he states that it resembles *P. toliapicus* Agassiz. This similarity is not apparent from Fowler's[9] description of *P. elegans* Marsh which is as follows:

[2] AGASSIZ, L. *Recherches sur les poissons fossiles.* **2**: 238–241, *pl. 69a, figs. 1–9.* 1833–1843.

[3] EASTMAN, C. R. *Pisces of Eocene of Maryland.* Md. Geol. Survey, Eocene, pp. 111–113. 1901.

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WOODWARD, A. S. *Catalogue of the fossil fishes in the British Museum,* part 4: 546–550. 1901.

WYMAN, JEFFRIES. *Notice of remains of vertebrate animals found at Richmond, Virginia.* Amer. Jour. Sci., ser. 2, **10**: 228–235. 1850.

ZITTEL, K. A. VON. *Textbook of paleontology.* **2**: 103. 1902.

[4] NICHOLSON, H. A. and LYDEKKER, R. *A manuel of paleontology for the use of students, with a general introduction on the principles of paleontology.* 3rd ed., 1004, *fig. 941.* 1889.

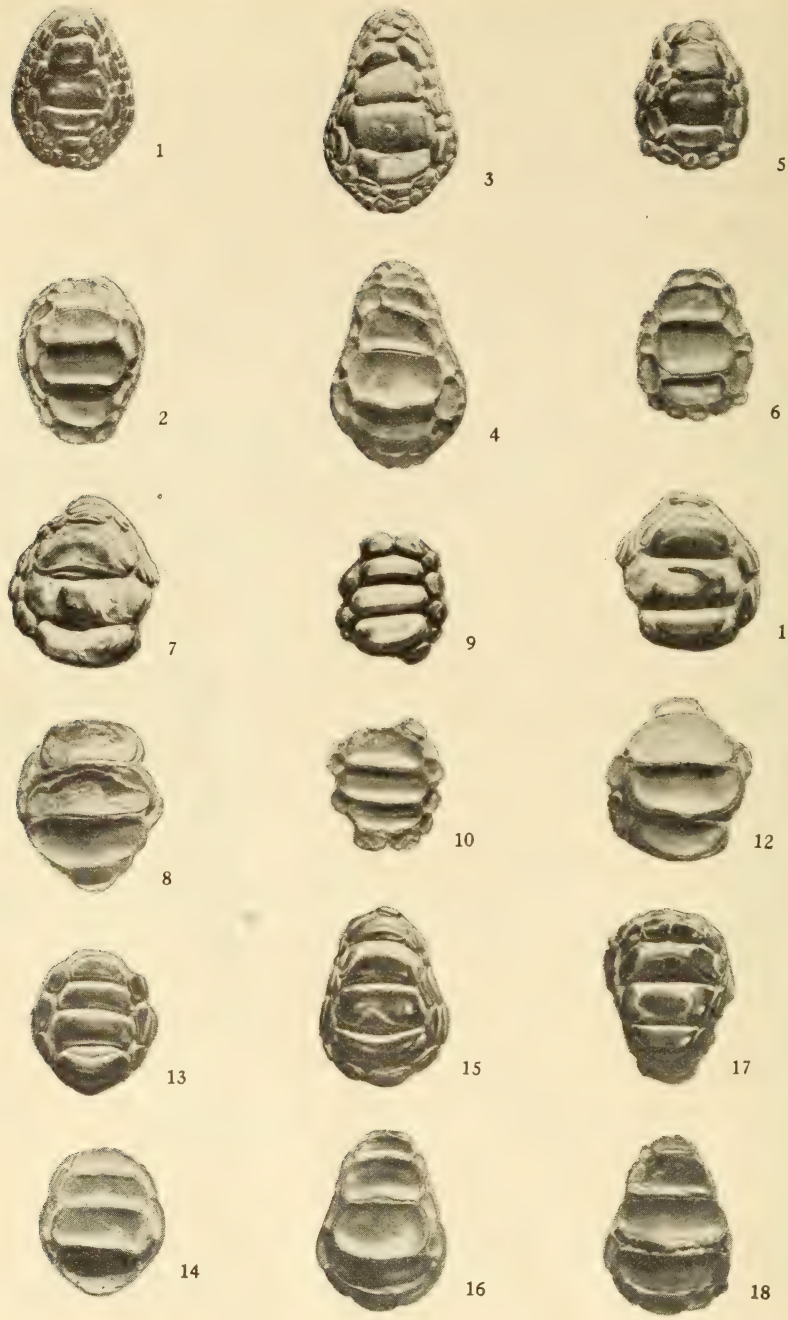
[5] MARSH, O. C. *Notice of some new Tertiary and Cretaceous fishes,* (Abst.). Proc. Amer. Assoc. Adv. Sci., 18th meeting, p. 228. 1870.

[6] AGASSIZ, *op. cit.*

[7] WYMAN, *op. cit.*

[8] MARSH, *op. cit.*

[9] FOWLER, H. W. *A description of the fossil fish remains of the Cretaceous, Eocene and Miocene Formations of New Jersey.* New Jersey Geol. Survey, Bull. **4**: 184–185. 1911.



Figures 1–18.

Figs. 1–6. *Phyllodus toliapicus* Agassiz. Figs. 1, 3, and 5, upper surfaces; Figs. 2, 4, and 6, corresponding lower surfaces.

Figs. 7–10. *Phyllodus speciosus* Cocchi. Figs. 7 and 9, upper surfaces; Figs. 8 and 10, corresponding lower surfaces.

Figs. 11–14. *Phyllodus marginalis* Agassiz. Figs. 11 and 13, upper surfaces; Figs. 12 and 14, corresponding lower surfaces.

Figs. 15–18. *Phyllodus medius?* Agassiz. Figs. 15 and 17, upper surfaces; Figs. 16 and 18, corresponding lower surfaces.

"Pharyngeal dental plate obtusely triangular, small, and triturating surface a little convex. Central teeth enlarged, circular well depressed or disk-like with central portion well pressed down, giving each tooth appearance of shallow cup. Only rims of each tooth covered with smooth enamel. Though most all teeth circular they vary into irregularities of circular design. Marginal teeth all smaller, similar, only with triturating surfaces less concave, and enamel extends equally over concave median portions. Successional teeth equally enlarged median as seen from lower surface, as they are above, and marginal teeth correspondingly reduced. Longest diameter 18 mm. The above-described example agrees with Marsh's account, which states the lateral or smaller teeth to be rather few."

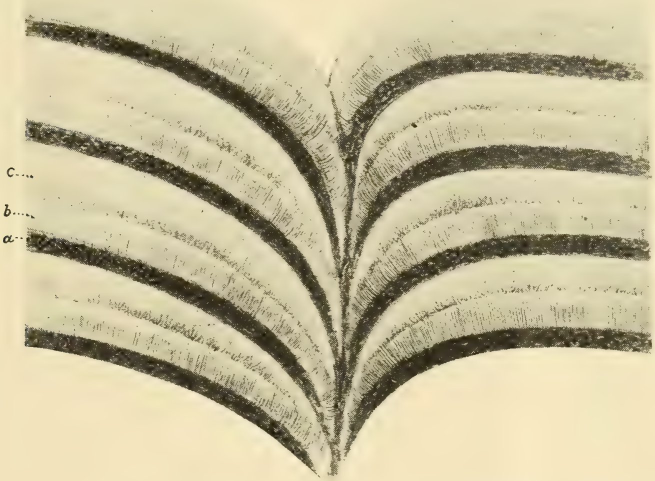


Fig. 19. A vertical longitudinal section of the continuous parts of four of the lamelliform teeth of *Phyllodus toliapicus: a.* Osseous base, *b.* Dentine, *c.* Enamel. (Plate 44, fig. 2 of Owen's Odontography.)

According to Fowler's description and figure of *P. elegans* Marsh, this species is apparently more closely related to the genus *Nummopalatus*[10] than it is to *Phyllodus*. Thus, of the four plates described by Wyman and Marsh, one has been referred to *P. toliapicus*, one unidentified, and two given new specific names, one of which (*P. elegans*) probably belongs to the genus *Nummopalatus*.

THE GENUS PHYLLODUS

Phyllodus was so named by Agassiz because of the leaf-like structure of the dentigerous plates.[11] One of the most concise descriptions

[10] SAUVAGE, H. E. *Note sur le genre* Nummopalatus *et sur les espèces de ce genre trouvées dans les terraines tertiaires de la France.* Bull. Soc. Géol. France (3) 3: 613–630, *pls. 22 and 23.* 1875.

[11] AGASSIZ, *op. cit.* p. 238. (φύλλον, a leaf and ὀδος, a tooth.)

of this genus is given by Owen[12] in his Odontography as follows:

"It consists of an anchylosed mass of superimposed more or less flattened, lamelliform teeth, of which those forming the middle longitudinal row are the largest, and present a transversely elongated oblong figure: these are surrounded by smaller oblong dental lamellae, irregularly placed, and diminishing in size to the circumference of the mass, where they exchange the oblong for a circular form."

The plates forming the middle row are not all the same size, those in the center being the largest. The dental plates or lamellae are usually convex on the upper surface and concave on the under or lower surface (Figs. 1–18). The lamellae are superimposed in nearly vertical tiers, the number of lamelliform teeth in each tier increasing from the anterior to the posterior part of the mass (Figs. 1–18), and according to Agassiz[13] they may vary from four to ten in number. Owen[14] has shown from his study of the microscopic structure of the teeth, that the large middle plates are also lamelliform, and similarly superimposed as the marginal lamellae (Fig. 19). The structure he believes is analgous to that of the pharyngeal teeth of *Scarus*. Agassiz,[15] however, says the lamellae are not composed in the same manner as the pharyngeal teeth of *Scarus*. In *Phyllodus* the lamellae are superimposed vertically and the entire exterior surface is triturating, while in the pharyngeal teeth of the *Scarus* the crown is more or less cut off.

In *Phyllodus* displacement and succession of the lamelliform teeth were accomplished in both vertical and longitudinal directions, analogous to the reproduction in the dental systems of *Diodon* and *Scarus* respectively, as described by Owen.[16] That is to say, the succession was both vertical and horizontal. As the teeth at the top of each tier were worn away, their loss was supplied by new lamellae added to the bottom of the tier. "But as the attrition was greatest at the anterior extremity of the dental plate, and the power of reproducing the lamellae in the vertical direction limited, the loss of entire piles of teeth was supplied by the addition of new piles to the posterior extremity of the dentigerous plate, according to the mode of reproduction described in the pharyngeal teeth of *Scarus*."[17] In *Scarus* the teeth are successively replaced at one extremity of the bone in proportion as they are worn away at the other; the course of succession being from

[12] Owen, Richard. *Odontography; or a treatise on the comparative anatomy of the teeth; their physiological relations; mode of development; and microscopic structure, in the vertebrate animals.* **1**: 138–141. *pl. 4, fig. 2; pl. 47, figs. 1–2.* 1840–1845.

[13] Agassiz, *op. cit.* p. 238.

[14] Owen, *op. cit.* p. 139.

[15] Agassiz, *op. cit.* p.

[16] Owen, *op. cit.* p. 141.

[17] Owen, *op. cit.* p. 141.

before backwards in the upper pharyngeals, and from behind forwards in the lower pharyngeal bones.[18]

MICROSCOPIC STRUCTURE

In view of the fact that Owen's Odontography may not always be readily accessible, his description of the microscopic structure of the lamelliform teeth of *Phyllodus* is quoted at length.

"The osseous substance (*a*, fig. 2, Pl. 44) is characterized by the large reticularly anastomosing medullary canals, without radiated cells in their interspaces, which are peculiar to the structure of the bones and ossified basis of the teeth in fishes. The dentine (*b*) consists of numerous, close-set calcigerous tubes and the clear uniting substance; the tubes are characterized by their straight and parallel course; at the middle part of the plate, they are directed vertically to its plane, and at the margins which are bent down, they incline so as to maintain the same relative position to that part of the surface of the plate; their diameter does not exceed 0.00007 inch; their subdivisions into pencils of smaller tubes takes place nearer to the enamel than usual. I could plainly discern the anastomoses of these divisions of the calcigerous tubes in some parts of the section. The enamel *c*, which, as in the denticles of the *Scarus* and many other fishes, closely approximates in structure to the dentine, exhibits, however, much less parallelism in the course of its component tubes in the *Phyllodus;* but these are as numerous and distinct, though somewhat more minute than those of the true dentine.

It would seem that in the matrices or pulps of both the enamel and dentine, the progress of calcification followed the same law, viz; from the circumference to the centre, or from the surface to the attached base of the pulp. In specimens of the *Scarus* preserved in spirit, and in other fishes, I find that neither surface of the formative pulps is free, for, that which may be termed the base of the enamel-pulp is adherent to the capsule, and while the base of the dental pulp turned in the contrary direction, coheres with the mucous surface, however, in each case that the process of calcification commences. The linear groups of cells being irregular in their position, form, by their confluence, tubes as irregularly disposed; but as the disposition of the hardening salts proceeds, the tubes become more regular and parallel. This parallelism has taken place in the *Phyllodus,* much sooner in the dentine than in the enamel, as is the case in the *Scarus,* which mainly distinguishes the textures of the dentine and enamel in fishes."

SYSTEMATIC DESCRIPTION

LABRIDAE

PHYLLODUS Agassiz

Specific determination of these plates is difficult, due to variations in the size, shape, and arrangement of the lamellae; and also to the discrepancies of identification in the literature. In addition, several of the plates are fragmentary and, therefore, may represent either the upper pharyngeal plates of larger forms, or possibly plates of young individuals. There is also the pos-

[18] OWEN, *op. cit.* p. 119.

sibility that these plates may occupy various positions in the dention and therefore not represent distinct species. This extinct genus is known only by the pharyngeal dentition and because of its extraordinary structure Agassiz[19] says it is very difficult to even say to which family it belongs. The validity of the many species which have been made of this genus may, therefore, be questionable. Agassiz says that the number of large teeth in *P. toliapicus* is less than in any other species, there being only three. Yet *P. polyodus* as figured by both Cocchi[20] and Woodward[21] has only three large teeth. Furthermore Agassiz describes *P. polyodus* as characterized by having four large teeth. *P. speciosus* as shown by Cocchi has only three large teeth.

Agassiz numbers the large teeth from the anterior border to the posterior, and this method will be followed in describing the plates figured in this paper.

The following species of *Phyllodus* are to be found in the literature.

toliapicus Agassiz
planus Agassiz
polyodus Agassiz
marginalis Agassiz
medius Agassiz
irregularis Agassiz
hipparionyx Eastman
corsicans Locard
gaudryi Priem
cretaceus Reuss
curvidens Marsh
elegans Marsh
petiolatus Owen
deborrei Winkler
subdepressus Münster
depressus Münster
secundarius Cocchi
colei Cocchi
hexagonalis Cocchi
speciosus Cocchi
bowerbanki Cocchi
submedius Cocchi
gervasi Cocchi
latidens Pomel
levesquei Pomel
duvalii Pomel
inconstans Pomel
incertus Michelotti
multidens Münster
haueri Münster
umbonatus Münster

Phyllodus toliapicus Agassiz

Figs. 1–6

1843. *Phyllodus toliapicus* Agassiz, Poiss. Foss., **2**: 239, *pl. 69a, figs. 1–3.*
1865. *Phyllodus toliapicus* Agassiz, I. Cocchi. Annali R. Mus. Fis. Stor. Nat. Firenze. 2nd ser. **1**: *pl. 2, fig. 8.*

Description.—An ankylosed mass of more or less flattened, lamelliform teeth, superimposed in nearly vertical tiers. The largest teeth, three in number, form the middle longitudinal row and are transversely elongated. These teeth are surrounded by from one to three rows of smaller, irregularly placed, oblong to circular, dental lamellae. The smaller dental plates diminish in size towards the circumference. In the row adjacent to the large teeth they are predominantly oblong, while in the succeeding rows they assume a more circular form. All of the lamellae are convex on the upper surface and con-

[19] Agassiz, *op. cit.* p. 238.
[20] Cocchi, I. *Monographia dei Pharyngodopilidae, nuova famiglia di Pesci Labroidi.* Annali del R. Museo di Fisica e Storia Naturale di Firenze, 2nd ser., **1**: *pls. 1–3.* 1865.
[21] Woodward, A. S. *A guide to the fossil reptiles, amphibians, and fishes, in the Department of Geology and Paleontology in the British Museum of Natural History.* p. 104, *fig. 115.* 1910.

cave on the lower. The general shape and arrangement of the dental lamellae are similar to those of the same species figured by Agassiz and Cocchi Figs. 1–2: maximum length, 23 mm.; maximum width, $17\frac{1}{2}$ mm.; maximum thickness, $5\frac{1}{2}$ mm. Figs. 3–4: maximum length, $29\frac{1}{2}$ mm.; maximum width, $19\frac{1}{2}$ mm.; maximum thickness, 6 mm. Figs. 5–6; maximum length, $21\frac{1}{2}$ mm.; maximum width, $16\frac{1}{2}$ mm.; maximum thickness, $4\frac{1}{2}$ mm.

PHYLLODUS SPECIOSUS Cocchi

Figs. 7–10

1865. *Phyllodus speciosus* Cocchi, I. Cocchi. Annali R. Mus. Fis. Stor. Nat. Firenze. 2nd ser. **1**: *pl. 2, figs. 5–6, pl. 1, figs. 6–8.*

Description.—This species is characterized by having three large teeth surrounded by two rows of smaller, oblong to circular, dental lamellae, superimposed in nearly vertical tiers. Figure 7 corresponds to Fig. 8, pl. 1 of Cocchi's monograph, and Fig. 9 to his Fig. 7, pl. 1. Although Agassiz in his original description of the genus says that *P. toliapicus* is the only species having but three large teeth, the specimens figured here correspond closely to those of Cocchi and for this reason have been identified as *P. speciosus*. Figure 7 resembles Fig. 11 somewhat but differs in the arrangement of the lamellae on the posterior border. In *P. speciosus* (Fig. 7) the dental lamellae are superimposed in nearly vertical tiers on the posterior border, while the lamellae occupying the corresponding position in *P. marginalis* are more terrace-like. A further difference between these species is in the number and arrangement of the large teeth. In *P. speciosus* the large teeth are three in number, the second being the largest and most elongated. In *P. marginalis* the large teeth are six in number, the largest being number four and the others decreasing in size towards the anterior and posterior borders. Figs. 7–8: maximum length, 24 mm.; maximum width, 21 mm.; maximum thickness, 7 mm. Figs. 9–10: maximum length, $17\frac{1}{2}$ mm.; maximum width,16 mm.; maximum thickness, 4 mm.

PHYLLODUS MARGINALIS Agassiz

Figs. 11–14

1843. *Phyllodus marginalis* Agassiz, Poiss. Foss., **2**: 240, *pl. 69a, figs. 8–9.*
1865. *Phyllodus marginalis* Agassiz, I. Cocchi. Annali R. Mus. Fis. Stor. Nat. Firenze, 2nd ser. **1**: *pl. 2, fig. 1.*

Description.—The specimens shown in Figs. 11–14 are incomplete. According to Agassiz the principal teeth of this species are six in number. In Fig. 11 the principal teeth present are numbers 3, 4, and 5; in Fig. 13 numbers 2, 3, 4, and 5. In both specimens some lateral, posterior, and anterior lamellae are absent. The following features are characteristic of this species. The posterior border is somewhat pointed and the lamellae are terrace-like rather than superimposed in vertical tiers as in the center and anterior border. Of the principal teeth the fourth is the largest and most elongated, the others decreasing in size towards both the anterior and posterior borders. The smaller dental lamellae present in these specimens are ovate as figured by Cocchi, and Agassiz describes them as being rounded, sometimes circular, and sometimes elliptical. The dental lamellae on the lower (concave) surface are larger than the corresponding teeth on the upper (convex) surface. Figs. 11–12: maximum length, 23 mm.; maximum width, $20\frac{1}{2}$ mm.; maximum thickness, $7\frac{1}{2}$ mm. Figs. 13–14: maximum length, 21 mm.; maximum width, $17\frac{1}{2}$ mm.; maximum thickness, $4\frac{1}{2}$ mm.

Phyllodus medius? Agassiz

Figs. 15–18.

1843. *Phyllodus medius* Agassiz, Poiss. Foss. **2**: 241. (Not figured.)
1865. *Phyllodus medius* Agassiz, I. Cocchi. Annali R. Mus. Fis. Stor. Nat. Firenze, 2nd ser. **1**: *pl. 2, figs. 10, 11, 12, 14.*

Description.—Agassiz does not figure this species in his "Recherches sur les Poissons Fossiles," but these specimens resemble *P. medius* Agassiz as shown by Cocchi in his monograph (Pl. 2, figs. 10, 11, 12, 14). This species resembles *P. toliapicus* Agassiz somewhat, but differs in the relative size, position, and arrangement of the smaller dental lamellae to the larger teeth. The large teeth are three in number and are surrounded by only one row of marginal dental lamellae, the other rows have been lost. As in the species already described, the dental lamellae are superimposed in nearly vertical tiers, convex on the upper surface, and concave on the lower. The lamellae on the posterior border are superimposed somewhat similarly to those in *P. marginalis* Agassiz, but as these specimens are fragmentary they cannot be said to be analogous in this respect. Figs. 15–16: maximum length, 26 mm.; maximum width, 18½ mm.; maximum thickness, 7 mm. Figs. 17–18: maximum length, 25½ mm.; maximum width, 18 mm.; maximum thickness, 6½ mm.

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ZOOLOGY.—*The snail* Pseudosuccinea columella (*Say*) *as a potentially important intermediate host in extending the range of* Fasciola hepatica *Linn.*[1] Wendell H. Krull, Bureau of Animal Industry. (Communicated by Maurice C. Hall.)

In an attempt to find a prolific snail which could be easily raised in the laboratory and used for experiments involving the infection of individual snails with a single miracidium, a new intermediate host for the sheep liver fluke, *Fasciola hepatica*, has been discovered. This host is the snail, *Pseudosuccinea columella*, identified by Mr. Wm. B. Marshall of the U. S. National Museum. According to Baker,[2] *P. columella* has a wide distribution, "Nova Scotia west to Minnesota, eastern Kansas and central Texas; Manitoba and Quebec south to Texas and Florida," in ponds and streams where water is more or less stagnant, a habitat in which lily pads or cat-tails (*Typha*) occur, being especially favorable. This distribution makes this snail an important host for *F. hepatica* east of the Mississippi river.

In a recent paper by Krull,[3] another new intermediate host, *Fossaria modicella*, was reported for the United States. With these snails and the snails previously reported by other authors as intermediate hosts of *F. hepatica*, it is apparent that the range of distribution of suitable host snails provides a factor favorable for a wide range of distribution of the parasite. Its present known range involves the West Coast States, the Rocky Mountain States, the South-west, the Gulf Coast States, Michigan, and probably Wisconsin. It is not known to be present in the East, and the records from the Middle West are

[1] Received March 30, 1933.

[2] Baker, F. C. *The fresh-water Mollusca of Wisconsin.* Wisc. Geol. and Nat. Hist. Survey Bull. **70**: pt. 1, 507 pp. 1928.

[3] Krull, W. H. *New snail and rabbit hosts for* Fasciola hepatica *Linn.* Jour. Parasit. (In press) 1933.

scattered and need further validation. Apparently the parasite's range could be extended throughout the greater part of the United States, and new enzoötic areas of fascioliasis in cattle and sheep may be expected to develop in the United States unless widespread control measures are undertaken and kept in effect. We have at least two species of snails in the East which will serve as hosts.

Not only does its wide distribution make *P. columella* a potentially important host snail, but observations concerning its ecology, both in its natural habitat and under controlled conditions, show that it might become an especially important host in some places because of its ability to tolerate acid water. The American snails previously incriminated as hosts have been species which prefer alkaline water. In the vicinity of Beltsville, Md., most ponds and streams are acid, and many ponds and streams with acid waters occur in the eastern United States. The pH of the water in the pond from which the writer collected the original stock of *P. columella* which were taken as a source for the laboratory-raised snails used in the experiment, has been recorded weekly for 8 months, July, 1932, to February , 1933, inclusive, and the pH has varied from 6.1 to 6.8, a reading of 6.4 having been recorded several times for as many as 4 consecutive weeks. The tolerance of this snail to acid water has been verified in the laboratory also. Colorimeters used in determining the above pH values were prepared by the LaMotte Chemical Products Company, Baltimore. Chlorphenol Red and Phenol Red were used for indicators.

P. columella has been raised in the laboratory for approximately 6 months. The original stock was collected from a small pond on the Bureau of Dairy Industry Farm, Beltsville, and consisted of only a small number of snails. These snails are very prolific and easily raised, a new generation having been produced about every two months under laboratory conditions during the winter months. These facts concerning the rearing of the snails are of some importance in that such information may prove to be valuable in correlating such factors as relative abundance of snails with such control measures as the application of copper sulphate to fields. For example, the effective reduction of the number of intermediate snail hosts over a given area would not be quite so easily accomplished with a snail having a short life cycle, such as *P. columella,* as with certain snails of the genus *Helisoma* in which the egg-laying period, as determined from laboratory observations is of comparatively short duration and occurs only once annually. Effective destruction of *P. columella* might necessitate re-

peated applications of copper sulphate, which might not be necessary in dealing with species of *Helisoma*.

In the experiment which resulted in the implication of *P. columella* as an intermediate host of *F. hepatica*, the third generation of laboratory-raised snails was used. All stock snails of this species have been kept in evaporating dishes in filtered water and fed on fresh lettuce. Twenty-three snails used in the experiment were hatched about December 8, 1932, and were transferred to a stender dish on December 25, 1932, when they were half grown. Several hundred miracidia were taken out of a container in which *F. hepatica* eggs were hatching, and transferred to the stender dish containing the snails. The 23 snails were left in the stender dish with the miracidia for about 4 hours and were then transferred to a fingerbowl of filtered water. Microscope observations previously made on this species of snail in the presence of miracidia, showed that the miracidia attached to and penetrated into the snail.

Two of the 23 snails in the experiment were dissected and examined for rediae January 11, 1933, and, apparently, were negative. Another snail was dissected January 24, 1933, and 8 mother rediae containing developing daughter rediae were recovered. The first of the 20 remaining snails shed cercariae on February 10, 1933, 47 days after being subjected to infection, and 17 of the remaining infected snails were shedding cercariae after 8 more days had elapsed. The 2 remaining snails were negative. The largest number of cercariae shed by a snail in a single day was 161. One snail which had been shedding cercariae for 2 days was examined and the liver contained 241 rediae and 356 mature cercariae. The results in the above infection experiment have been verified in subsequent experiments by the writer.

ZOOLOGY.—*Descriptions of two new parasitic nematodes from birds.*[1] EVERETT E. WEHR, Bureau of Animal Industry. (Communicated by BENJAMIN SCHWARTZ.)

The first parasite described in this paper was collected by E. A. Chapin from the gizzard of a whistling swan, *Cygnus columbianus*, which died May 5, 1924 at the National Zoological Park, Washington, D. C. This nematode belongs to the family Amidostomidae Baylis and Daubney, 1926, subfamily Amodostominae Travassos, 1920, genus *Amidostomum* Railliet and Henry, 1909. Since the species in

[1] Received April 22, 1933.

question possesses certain characters which differ from those of any of the described species of the genus, it is considered, in this paper, as a new species.

Amidostomum cygni, n. sp.

Diagnosis.—Body very slender. Cuticle with fine transverse striations. Head slightly constricted at base of lips. Lateral alae absent. Oral opening circular, surrounded by four pairs of submedian cephalic papillae and one pair of amphids (Fig. 3). Buccal cavity with relatively thin walls; three triangular teeth at base of buccal cavity; one tooth large, with a broad base and a curved tip, and two remaining teeth smaller, about equal in size, with pointed tips. Anterior end of esophagus slightly swollen (Fig. 4).

Male 12 to 13 mm. long by 177μ in maximum width. Esophagus 1.16 mm. long, slightly dilated at its anterior end. Nerve ring about 309μ from anterior extremity. Prebursal papillae present. Bursa with lateral lobes only slightly longer than the dorsal lobe (Fig. 5). Externo-lateral ray thick, bent near its tip in an anterior direction, so that it does not reach edge of the bursa (Fig. 5). Postero-lateral and medio-lateral rays united for about one-half or more of their lengths, both rays reaching edge of bursa. Externo-dorsal ray shorter than dorsal ray, and arising from the same stem. Dorsal ray about 70μ long, bifurcated terminally, and extending to tip of dorsal lobe, terminal branches bidigitate. Spicules equal, about 170μ long, similar in shape to those of other species of genus (Fig. 5). Gubernaculum slender, about half the length of spicules (Fig. 5).

Female 16 to 17 mm. long by 188μ in maximum width. Esophagus 1.22 mm. long. Vulva about 3.5 mm. from posterior end of body. Tail about 2.85 mm. long, abruptly narrowed posterior to anal opening, its posterior extremity rounded. Eggs oval, 58 to 62μ long by 35μ wide.

Host.—Whistling swan, *Cygnus columbianus.*

Location.—Underneath tunic lining of gizzard.

Locality.—National Zoological Park, Washington, D. C.

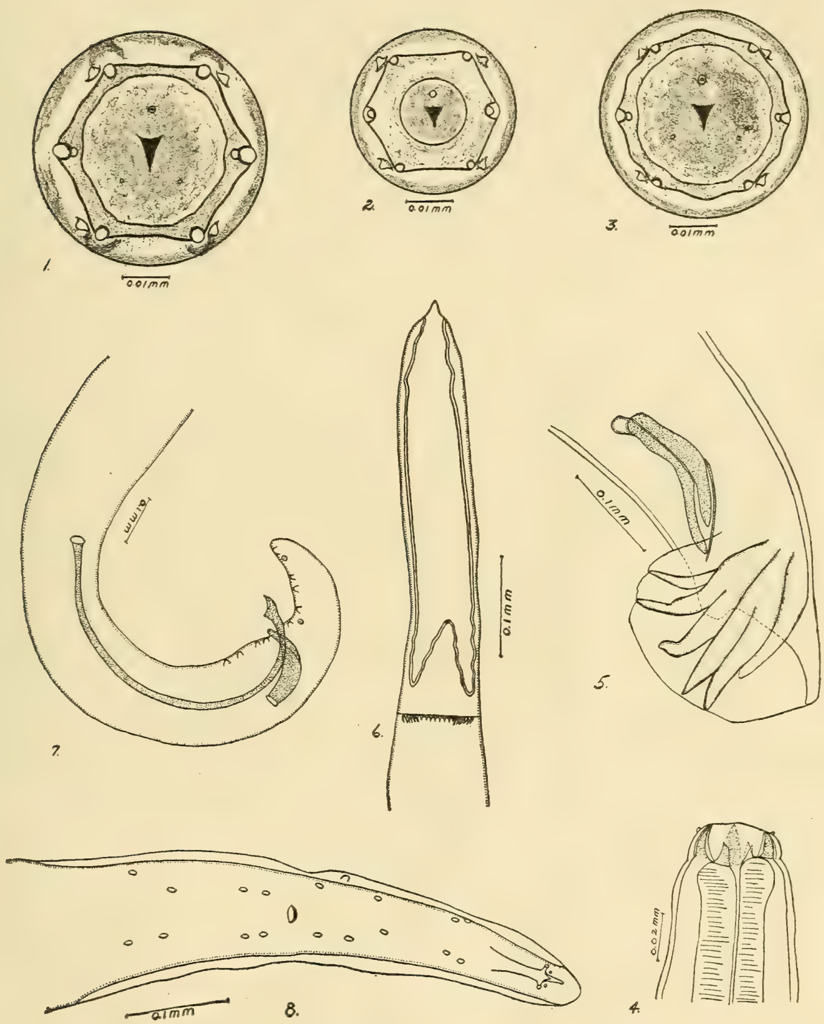
Type specimens (male and female).—U. S. N. M., Helminthological Collection, No. 26142.

Paratypes.—U. S. N. M. Helminthological Collection, No. 26142.

Inclusive of the species described in this paper, the genus *Amidostomum* now contains 10 species. Baylis[2] considered *A. fuligulae* Maplestone, 1930 and *A. anatinum* Sugimoto, 1930 synonyms of *A. skrjabini* Boulenger, 1926. So far as can be judged from available descriptions of these 3 species, this view appears sound. Cram[3] stated that *A. skrjabini* was possibly a synonym of *A. chevreuxi* Seurat, 1918, but, according to Baylis,[2] this synonymy should not be established until a study of the type material of *A. chevreuxi* has been made, or until specimens from the type host, *Himantopus himantopus*, have been examined for comparison with Baylis's redescription of the type specimens of *A. skrjabini. Amidostomum leucopariae* Solonitsyn 1928 must be

[2] Baylis, H. A. *A comparison of certain species of the nematode genus* Amidostomum, *with a description of a new species.* Ann. and Mag. Nat. Hist., ser.10, 10 (57): 281–287. 1932.

[3] Cram, E. B. *Bird parasites of the nematode suborders Strongylata, Ascaridata, and Spirurata.* U. S. Nat. Mus. Bull. 140. 1927.



Figures 1–8. 1. *Amidostomum spatulatum*, anterior end (*en face* view); 2. *Amidostomum chevreuxi*, anterior end (*en face* view); 3. *Amidostomum cygni*, anterior end (*en face* view); 4. *Amidostomum cygni*, anterior end of female (lateral view); 5. *Amidostomum cygni*, posterior end of male (lateral view); 6. *Pectinospirura argentata*, anterior extremity of male (lateral view); 7. *Pectinospirura argentata*, posterior end of male (lateral view); 8. *Pectinospirura argentata*, posterior end of male (ventral view).

considered a *nomen nudum*, as no description accompanied this name.

Except for the species *A. acutum* (Lundahl, 1848) Seurat, 1918, and *A. fulicae* (Rudolphi, 1819) Seurat, 1919, which have been imperfectly described, the species of the genus *Amidostomum* may be divided into two distinct groups, based on the number of teeth present in the buccal cavity, namely, (1) those species possessing one tooth and, (2) those with three teeth. *Amidostomum monodon* (Linstow, 1882) Skrjabin, 1915, *A. chevreuxi*, and *A. skrjabini* fall into the first group, while *A. anseris* (Zeder 1800) Railliet and Henry, 1909, *A. henryi* Skrjabi, 1915, *A. spatulatum* Baylis, 1932, *A. raillieti* Skrjabi, 1915, and the species described in this paper, *Amidostomum cygni*, belong to the second group.

The species of the genus *Amidostomum* may be readily identified with the aid of the following key:

KEY TO THE WELL DESCRIBED SPECIES OF AMIDOSTOMUM[4]

1. Without teeth in buccal cavity 2
   With teeth in buccal cavity 3
2. Male 8.58 mm., female 9 mm. long; vulva 1.56 mm. from posterior extremity; spicules 175μ long . . . . *A. fulicae*
   Male 10 to 14 mm., female 14 to 17 mm. long; vulva 2.8 to 3.1 mm. from posterior extremity; spicules not described . . . . *A. acutum*
3. Buccal cavity with single tooth at base . . . . *A. chevreuxi*
   Buccal cavity with three teeth at base 4
4. Externo-dorsal rays arise in common with dorsal ray; lateral lobes of bursa only slightly longer than dorsal lobe 5
   Externo-dorsal rays do not arise in common with dorsal ray, but originate near the base of the common stem from which all rays in the lateral lobes arise; lateral lobes of bursa much longer than dorsal lobe 6
5. Ventral process of each spicule ends in a large, laterally flattened expansion; cuticle of anterior end of head noticeably swollen about each of the submedian papillae . . . . *A. spatulatum*
   Ventral process of each spicule does not end in a large, laterally flattened expansion; cuticle of anterior end of head not noticeably swollen about each of the submedian papillae . . . . *A. cygni* n. sp.
6. Buccal cavity 15 to 18.5μ wide; male 8 mm., female 14.5 mm. long; spicules 166μ long . . . . *A. henryi*
   Buccal cavity 27.5μ or more wide; spicules 200 to 300μ long 7
7. Male 5.5 to 7.9 mm., female 6.8 to 9.3 mm. long; vulva 1.3 to 1.8 mm. from posterior end of body . . . . *A. raillieti*
   Male 10 to 17 mm., female 12 to 24 mm. long; vulva 2.4 to 4.8 mm. from posterior end of the body . . . . *A. anseris*

The species described below represents a new genus as well as a new species; it was collected from the proventriculus of a herring gull, *Larus argentatus smithsonianus*, on September 3, 1931, at Vineland,

[4] *A. monodon* and *A. skrjabini* have not been included in the following key. *A. monodon* has been rather inadequately described, and *A. skrjabini*, so far as its morphology is known, lacks morphological character which can be used to separate it from *A. chevreuxi*.

New Jersey, by J. J. Black, and from ulcers of the proventriculus of a laughing gull, *Larus atricilla* (=*Chroicocephalus atricilla*), on June 11, 1926, at Washington, D. C., by E. B. Cram. The presence of cordons readily identifies these specimens as belonging to the family Acuariidae Seurat, 1913, subfamily Acuariinae Railliet, Henry and Sisoff, 1912. The structure of the cervical papillae, which are located at the base of the cordons, does not permit the allocation of these forms to any of the existing genera in that subfamily. Each cervical papilla consists of a transverse row of about 20 posteriorly directed spines; this very unique feature differentiates the new genus from the closely related genus *Synhimantus*, in which the cervical papillae are tricuspid.

Pectinospirura, n. g.

Diagnosis.—Oral opening dorso-ventrally elongate, surrounded by two large lateral pseudolabia, each of which bears two submedian cephalic papillae and one large amphid. Cordons recurrent, anastomosing, and extending, in type species, a short distance beyond first division of esophagus. Esophagus composed of two parts. Spicules unequal in size and dissimilar in structure.

Type species.—Pectinospirura argentata, n. sp.

Specific diagnosis.—Cordons extend to a level slightly posterior to junction of anterior (muscular) and posterior (glandular) portions of esophagus; cordons anastomose shortly after turning anteriorly (Fig. 6). Each cervical papilla consists of a transverse row of approximately 20 posteriorly directed spines; outer spines curved slightly inwards and larger than the others (Fig. 6). These cervical papillae are probably homologous with the cervical papillae of *Synhimantus*, *Streptocara* and other genera of the subfamily Acuariinae possessing such characters.

Male 6 to 6.5 mm. long by 267μ wide. Buccal cavity narrow, 285 to 310μ long. Anterior portion of esophagus 560 to 570μ long, posterior portion 2.75 to 3 mm. long. Nerve ring 392μ from anterior extremity. Cordons extend posteriorly for about 1 mm., or about 1/5 of total length of body; at this level they turn anteriad and anastomose about 125.6μ from point of turning. Tail rounded, 283μ long. Four pairs of preanal and seven pairs of postanal papillae present (Fig. 8). Spicules unequal, long spicule about 816μ long, slender and terminating in a hook-like tip; short spicule about 188μ long, stout, and ending in a rounded tip (Fig. 7).

Female 6.5 to 7.0 mm. long by 314μ wide. Buccal cavity 309μ long and narrow. Anterior portion of esophagus 556μ long, posterior portion 3.1 mm. long. Nerve ring 417μ from anterior extremity. Cordons extend for a distance of about 1.12 mm. along sides of body, from which point they turn anteriad and anastomose at about the same distance from point of turning as in the male. Vulva in posterior half of body, about 1.34 mm. from posterior end. Eggs 44μ by 28μ.

Hosts.—Herring gull, *Larus argentatus smithsonianus*, and Laughing gull, *Larus atricilla.*

Location.—Proventriculus.

Locality.—Vineland, New Jersey and vicinity of Washington, D. C.

Type specimens (male and female).—U. S. N. M., Helminthological Collection, No. 30574.

Paratypes.—U. S. N. M., Helminthological Collection, No. 30574.

The genera of the subfamily Acuariinae may be differentiated with aid of the following key:

KEY TO GENERA OF ACUARIINAE

1. Cordons not recurrent and not anastomosing 2
   Cordons recurrent or anastomosing, or both 3
2. Both spicules thick and only slightly unequal; 6 to 8 pairs of postanal papillae . . . . *Acuaria*
   Spicules markedly dissimilar in structure and very unequal in size; 5 to 7 pairs of postanal papillae . . . . *Cheilospirura*
3. Cordons not recurrent, but anastomosing 4
   Cordons recurrent, anastomosing or separate 6
4. Cuticle raised in front of postcervical papillae to form large collar or sheath, cordons anastomose on free border of collar . . . . *Chevreuxi*
   No such collar or sheath present 5
5. Cordons confined to cephalic region; cuticle of head inflated . *Avicularietla*
   Cordons not confined to cephalic region; cuticle of head not inflated . . . . *Echinuria*
6. Cordons recurrent, but not anastomosing . . . . *Dispharynx*
   Cordons recurrent and anastomosing 7
7. Cordons form loop directly after their origin on head; cordons not flat against body, but applied to margin of plates or alae; lateral alae present on body . . . . *Cosmocephalus*
   Cordons lacking loops at anterior ends; cordons applied directly to body; no lateral alae 8
8. Chitinous structures (cervical papillae) at base of cordons tricuspid in structure . . . . *Synhimantus*
   Chitinous structures (cervical papillae) at base of cordons each consisting of about 20 posteriorly directed spines . . . . *Pectinospirura*

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

497TH MEETING

The 497th meeting of the Society was held in the Assembly Hall of the Cosmos Club, January 11, 1933, President C. N. FENNER presiding.

Informal communication.—W. P. WOODRING reviewed a treatise on the structure of mollusc shells by O. B. Bloggild of Denmark. The study was based on a microscopic examination of a large number of shells and the shell characters thus determined will prove to be of considerable value for systematics.

Regular program: RICHARD E. FULLER—*Complex diabasic intrusives causing local contact fusion.*

Discussed by Messrs. FENNER and R. C. WELLS.

JULIAN D. SEARS: *Regressive sandstones.*—The Upper Cretaceous formations of the Rocky Mountain region present widespread examples of intertonguing of marine and continental deposits which, recognized as formed in or adjoining a shallow epicontinental sea, indicate repeated advances and retreats of that sea.

In trying to visualize the conditions and processes that led to such intertonguing, the writer finds that transgressive deposits seem readily understandable but that those of regression are more puzzling and elusive. He senses that others have shared his difficulty, for in many text-books and articles regressive deposits have been either slighted or else explained in varying ways that seem open to question. The concept perhaps most frequently outlined is that the strandline moved outward because of a relative lowering of sea level, and that in consequence newer near-shore deposits were laid down on earlier off-shore deposits; moreover, the concept usually invokes conditions and processes observed today on the continental shelves facing the open ocean.

As the several conflicting explanations and possibilities are weighed, there seems reason for serious doubt as to whether thick, widespread and relatively uniform regressive sandstones, conformably overlying marine shales through a thin transition zone and overlain by continental deposits of lenticular sandstones, clay, and coal, could have formed under the conditions of the continental shelf, whether the sea level was rising, falling, or stationary. The edge of the shelf, at about the maximum depth of wave action, stands as a constant control over possible deposition on the shelf, for beyond its edge are the great ocean deeps, a ready dumping ground for surplus sediment. Though detailed analysis of the several possibilities can not be made in this brief statement, a few significant points may be mentioned. With falling sea level, wave base and the profile of equilibrium established for deeper water are disturbed and lowered, and the tendency is not for further deposition but for erosion of earlier deposits and their transportation to the ocean abyss. With stationary level and even more with a rising sea, the tendency is for transgressive deposition; regressive deposits could be formed only briefly or locally by prograding caused by abnormal excess of debris supply over the usually predominant transporting power of waves and currents. Moreover, it seems questionable whether even under such unusual conditions the sand for miles outward from the old shore could be built to sea level and covered by continental material.

Conditions in an epicontinental sea were obviously very different. Its shallowness, the weaker wave and current action, the relatively greater surrounding land areas contributing sediment, the great distances to the ocean deeps, and the consequent slow outward movement of debris, combined to flatten the profile of equilibrium and to make possible repeated fillings of large areas of the basin to or above sea level. Accumulation of thousands of feet of shallow-water sediments shows that the floor of the geosyncline moved slowly and predominantly downward. Temporary reversals of such movement, causing a shallower sea, would perhaps make easier the task of basin filling. However, the writer believes that such reversals of movement, though occasionally found, were not normal and to be expected, whether the general sinking of the geosycline was caused by isostatic adjustments or by lateral pressure. Nor do they seem to be required to explain regressive sedimentation. He prefers the concept that movement of the geosynclinal floor was always downward but that the rate varied; rapid movement as a relief of earth stresses was followed by slower movement or perhaps long periods of standstill during accumulation of new stresses. Rapid sinking brought the sea over the land, the rapidity of the advance perhaps causing the observed tendency for the transgressive sandstones to be thinner or absent at many places. As the rise of sea level slowed down and perhaps ceased, the sediments which continued to be supplied in abundance by the erosion of the recently uplifted landward masses began to fill the basin more rapidly, and the near-shore sands rose to and above sea level, prograding outward over the earlier muds and hence pushing the shore seaward. These sands in turn were buried by the accumulation of lagoonal and fluviatile deposits, which gathered until renewed sinking of the geosyncline caused another advance of the sea and the beginning of new transgressive deposits. (*Author's abstract.*)

Discussed by Messrs. Hunt, Capps, Rubey, and Stevenson.

498th meeting

The 498th meeting of the Society was held in the Assembly Hall of the Cosmos Club, January 25, 1933, President C. N. Fenner presiding.

Program: J. B. Mertie, Jr.: *Selected problems of the geology of the Yukon-Tanana region, Alaska.*—The Yukon-Tanana region is an area of about 38,000 square miles lying between the Yukon and Tanana Rivers in east-central Alaska. Systematic surveys of this region were begun by L. M. Prindle, of the U. S. Geological Survey in 1903, and were continued by him until 1911. Between 1911 and 1931, the writer spent 7 field seasons in the continuation of this work, and many others have also participated. A general geologic report upon the whole region is now in preparation.

The geologic section of the Yukon-Tanana region is unusually complete. Sedimentary rocks of every geologic system, except the Jurassic, are represented, and granitic, basic, and intermediate intrusives and extrusives of several ages are also recognized. In the present paper the writer outlines the salient features and problems of the pre-Cambrian and lower Paleozoic sections, and also compares briefly the granitic rocks of three ages.

The pre-Cambrian section consists of an older group of crystalline rocks of sedimentary origin, known as the Birch Creek schist, and certain younger non-crystalline rocks, which comprise at least parts of the Tindir and Tatalina groups. The ancient crystalline rocks also include igneous members, but these are not included in the Birch Creek schist. The sedimentary crystalline rocks may best be studied in their type locality, between Fairbanks and

Circle, where relatively few igneous members are present. The most important of the meta-igneous rocks is the Pelly gneiss, which is well developed in the Fortymile district. The other igneous rocks include amphibolite, hornblende schist, and certain chlorite, albite, and epidote schists.

The Tindir group consists of at least 20,000 feet of little altered rocks which are younger than the Birch Creek schist, but underlie the Middle Cambrian rocks. These rocks comprise a great variety of sediments, which include dolomite, shale, red beds, basic lavas, quartzite, and other rocks. The uppermost horizons may possibly be of Lower Cambrian age, but the group as a whole is correlated with the Belt series (Algonkian) of British Columbia. These rocks present many problems of sedimentary petrology and structure and may also yield fossils, if systematically studied.

The Tatalina group is believed to be largely of pre-Cambrian age, but also includes some early Ordovician rocks which it has not been practicable to map separately. The quartzite, arkose, and graywacke that characterize most of the Tatalina group probably represent the basal horizons of the late pre-Cambrian sequence of this region. The Tatalina group is not believed to include any sediments of Cambrian age, and this interpretation introduces a stratigraphic hiatus in the section, which constitutes a major problem in the geologic history.

The Cambrian rocks include an Upper Cambrian limestone, characterized by the type fossils *Acrothele*, *Acrotreta*, and *Obolus*, and a Middle Cambrian sequence, chiefly limestone, which is characterized by the primitive corals *Archaeocyathus* and *Ethmophyllum*. About 3,300 feet of Cambrian sediments have been recognized, but the Upper and Middle Cambrian rocks have not been found in a continuous sequence, so that the total thickness of Cambrian rocks may be greater than this.

The Ordovician rocks likewise have been studied at different localities and present difficult problems of correlation. Along the international boundary the sequence consists of Lower and Middle Ordovician limestones, with a graptolite facies of Middle Ordovician age; whereas, in the White Mountains, the sequence consists of black argillite and chert, of Lower Ordovician age, followed by a group of basic volcanics of Middle Ordovician age.

The Silurian is represented mainly by a massive limestone, of middle and upper Silurian age, which has been traced in the form of a horseshoe for more than 1,000 miles through northern, central, and southwestern Alaska. One side of the shoe lies in Brooks Range; the toe is along the international boundary; and the other side of the shoe passes through the Yukon-Tanana region. The type fossils are *Conchidium* and *Clorinda*. A great unconformity separates the Silurian rocks from the Middle Devonian and later Paleozoic rocks.

The oldest granitic rocks are those of the Pelly gneiss, which are probably of pre-Cambrian age. The great batholithic intrusives of the region are of Mesozoic age, possibly intruded in the Jurassic. These intrusives are normal granites and quartz diorites, but they present many problems of contact metamorphism and ore deposition. The youngest granitic rocks are of Tertiary age. These are monzonitic rocks which show abnormal petrographic and chemical characters, and fall into little known subrangs in the quantitative chemical classification of igneous rocks. (*Author's abstract.*)

Discussed by Messrs. RESSER, GOLDMAN, STANTON, KING, and BUTTS.

T. A. HENDRICKS: *Some Pleistocene changes in the course of the Canadian River of southeastern Oklahoma.*—In Tertiary time the Canadian River flowed

eastward from the Rocky Mountains to the Mississippi River on a broad old age surface. In late Tertiary or early Pleistocene time the portion of the river lying in southeastern Oklahoma was rejuvenated and cut downward establishing grade about 200 feet lower.

Once grade was reached at this lower level, the river began meandering and building up a wide flood plain underlain by sand, gravel, and clay, extensive remnants of which now remain as the Guertie sand of southeastern Oklahoma. Many disconnected areas of the sand form a narrow winding belt extending eastward from Byars in Pottawatomie County to Gaines Creek in Pittsburg County, a distance of about 90 miles. This belt passes several miles south of McAlester and is there about 25 miles south of the present course of the river. The gravel in the Guertie sand consists of quartz, quartzite, chert, flint, jasper, and silicified wood of Cretaceous age, which came either from the rocks exposed in the Rocky Mountains or from the Tertiary deposits of the High Plains that were derived from rocks of the Rocky Mountains. The only evidence of the age of the Guertie sand is a single elephant tusk reported by G. D. Morgan, who believed it to be of Pleistocene age.

The gravel in the Guertie sand is confined to the main channel formerly occupied by the Canadian River and to three other areas not directly connected with the main channel. Much of the sand and clay appears to have been deposited in branch channels occupied by the waters of the Canadian River only in times of flood. Such waters would be able to carry and deposit the finer materials but would not have sufficient velocity to transport gravel.

The presence of gravel in the three areas not directly connected with the main channel indicates that the full volume of the river must have flowed over these three areas at some time and hence that there were several changes in its course. As the course of the Canadian River in Guertie time was inherited from an old age surface it was circuitous and not adjusted to the structure of the underlying rocks. Consequently, a tributary more favorably situated structurally was able to cut headward and divert the waters of the river into a shorter course. This resulted in erosion of the new channel, due to the increased gradient, and was followed by deposition as soon as grade was reestablished at lower level. Thus we now find sand and gravel at a higher level in an older indirect course of the river and at a lower level in the more recent and shorter course.

Three such changes in the course of the Canadian River occurred. The first change was small and shifted the stream to the southeast. The second was larger, and the third still larger but both these changes shifted the stream northwestward and straightened its course. The last change shifted the river into its present course.

At the present time tributaries of the Red River are cutting headward and capturing some of the former drainage of the Canadian River. One of these tributaries, Muddy Boggy Creek, within $2\frac{1}{2}$ miles of the Canadian River about 10 miles northeast of Ada is actually lower than the Canadian where the two streams are nearest each other. In time, it is likely that the Canadian will be diverted into the Red and will pursue an even shorter course to the Gulf of Mexico. (*Author's abstract.*)

Discussed by Messrs. SEARS, COOKE, ELIAS, McKNIGHT and HENBEST.

C. P. ROSS: *Some features of the Idaho batholith.*—The Idaho batholith intruded Belt strata over much or all of its central portion and Paleozoic

beds on both sides. Considerable areas of it are covered by Tertiary and later strata which rest on its eroded surface.

It is believed that the area now occupied by the batholith is a positive element in the earth's crust which has for the most part been above sea level since the end of the Algonkian. During much or all of the Paleozoic the western shore of the interior or Cordilleran sea coincided in position approximately with the eastern border of the present exposure of the batholith. The greatest geosynclinal accumulations in the Paleozoic were just east of the present Idaho batholith while comparable thicknesses of Mesozoic beds were deposited in a trough 150 miles or so farther east.

The Idaho batholith is composed mainly of somewhat calcic quartz monzonite. In general it is believed to have been intruded essentially as a unit rather than as an aggregate of discrete bodies such as compose the batholith of the Sierra Nevada.

In the outer portions of the batholith wherever strata of probable Belt age are preserved there is an irregular shell of gneiss, commonly dioritic, which, wherever the relations can be determined, is older than the quartz monzonite. The dioritic gneiss commonly includes and is associated with Belt rocks more or less thoroughly injected and replaced by the igneous material. It is noteworthy that Paleozoic rocks on the flanks were metamorphosed but very little injected as a result of the intrusion.

It appears that the Idaho batholith had, over much of its extent, a nearly flat roof and comparatively steep, outward-sloping sides, with a transverse depression in the roof along the westward flowing section of the Salmon River between Shoup and Riggins. The roof has been less deeply and completely cut into in northcentral than in southcentral Idaho but even in the latter region erosion has not yet penetrated so very far below the original roof.

The Belt strata are flexed, metamorphosed and locally broken by thrust faults, in part possibly pre-Permian. In remnants of such rocks in the batholithic roof there is commonly conspicuously less close folding than in the Paleozoic rocks on the eastern flank. The latter are characterized by closely compressed overturned, pinched and broken folds. Overturning and overthrusting are in general toward the northeast. There is evidence that the intrusion of satelitic stocks was accompanied by deformation and fracturing. Both the stocks and the main batholith came into their present position subsequent to at least much of the close folding but possibly before thrust faulting had ceased. The anticline immediately east of the east flank of the main batholith conforms closely in trend to the sinuosities of the igneous contact.

It appears that the intrusion of the Idaho batholith played a major role in the diastrophism of the region. Possibly the long continued upward tendency of the earth block now containing it is connected with deep-seated hydrostatic adjustments of magma such as are required by Keith's concept of batholithic intrusions as one of the immediate causes of mountain building.

It is thought that the Idaho batholith corresponds more closely in age with the intrusions of post-Triassic and pre-Upper Cretaceous age to the west and north than to such apparently younger intrusions as the Boulder batholith farther east. There is evidence pointing to an eastward migration of both intrusive igneous activity and orogenic movement. (*Author's abstract.*)

Discussed by Messrs. FERGUSON, HEWETT, and SHENON.

499TH MEETING

The 499th meeting of the Society was held in the Assembly Hall of the Cosmos Club, February 8, 1933, President C. N. FENNER presiding.

Informal communication.—W. W. RUBEY described a qualitative test for phosphate rocks of commercial grade and mentioned some of its limitations. Concentrated hydrochloric acid applied to specimens with a tricalcium phosphate content exceeding 25 per cent yields, on evaporation, a powder that is at first yellow but changes to white. The test failed on porous specimens of high $CaCO_3$ content; and gave a somewhat similar, though distinguishable, precipitate or residue on specimens of manganiferous siderite free from phosphate.

Regular program: G. A. COOPER: *Stratigraphy of the Hamilton Group of New York.*—The outcrop belt of the Hamilton Group of rocks here described extends from Lake Erie nearly to the Hudson River. The Hamilton Group forms a huge wedge of clastic sediments resting on the Onondaga limestone, which thickens eastward from 285 feet at Lake Erie to 2450 feet in Schoharie Valley in eastern New York. Three facies are distinguishable in the group: a black shale facies carrying a *Leiorhynchus* or Marcellus fauna, which descends in the section to the east; this black shale facies is replaced eastward by an argillaceous sandstone facies containing a *Tropidoleptus* or Hamilton Fauna, which rises in the section to the west. In eastern New York, at the base of the Catskill Mountains the upper three-quarters of the Hamilton are replaced by red beds of the continental facies. In western New York the Hamilton is unconformably overlain by the Tully limestone but in eastern New York there is no evidence for unconformity. (*Author's abstract.*)

Discussed by Mr. BUTTS.

S. R. CAPPS: *An air reconnaissance of Middleton Island, Alaska.*—Middleton Island lies in the Gulf of Alaska about 70 miles out to sea from the nearest mainland, and 50 miles from the nearest island, and is separated from them by water 50 to 100 fathoms deep. An attempt to visit it by airplane was unsuccessful, as no landing could be made, but a comprehensive view of it was had, and an excellent series of photographs was obtained. The island is about 7 miles long, 2 miles wide and 120 feet high. Its surface is fairly flat, and it is bordered around most of its circumference by wave cut cliffs that afford excellent exposures. The bedrock is composed of moderately indurated sandstone and conglomerate that dips some 30° to the northwest, and has been leveled across by a wave cut platform. Unconformably upon this wave-cut surface is a layer of a few to 30 feet or so of coarse gravel and boulders of material much of which is foreign to the island and resembles that found on the islands and mainland to the north and west. The island surface shows a well preserved set of beach terraces to its top, showing relatively recent emergence. The upper half dozen terraces are each only a few feet high and show that the island emerged by pulsations, with numerous short halts, but has remained relatively stable at its present stand. A considerable wave cut platform has been and is now being cut at the present effective wave base.

The most reasonable explanation for the large amount of foreign boulders on the island surface is that they were transported to the site of the island by ice, either on bergs discharged from tidal glaciers, or by the Pleistocene glaciers themselves, which may have coalesced to form an ice shelf that reached as far out to sea as this island. In view of the great quantity of this foreign material direct transportation by glaciers seems the most probable explanation of its presence. Actual close hand study on the island will be

necessary before the observations here cited can be considered as final. (*Author's abstract.*)

Discussed by Messrs. BRADLEY, TRASK, MCKNIGHT, and FENNER.

M. K. ELIAS: *The Ogallala formation of the High Plains, Kansas.*—The Ogallala formation (lower Pliocene) of northwestern Kansas and the surrounding territory is a continental deposit which is built chiefly by unsorted grit and loam in places as much as 210 feet thick. Only a small part of this material was reworked and redeposited by action of streams and rivers of Ogallala time; this part constitutes broad channel—and lens-like bodies of sandstone and gravel, which are often distinctly cross-bedded. Thin beds of white porous limestone and rare deposits of diatomaceous marl are known in the middle and upper parts of the formation. Scattered lenses and beds of volcanic ash occur locally in the upper part of the Ogallala, whereas green and chocolate-brown bentonitic clays are confined to the lower half of the formation. Toward the top of the Ogallala the unsorted grit and loam usually grade into porous "caliche"-like sandy limestone, which in some areas is capped by 2 to 3½ feet of dense pink limestone with an irregularly concentric structure; this is the algal (*Chlorellopsis*) limestone of the author. The most common fossils in the Ogallala are siliceous protective covers of grass seeds, calcareous and siliceous nutlets of herbs of the Borrage family, and calcareous hackberry pods. The perfect preservation of sharp edges and minute cusps, bristles, and hairs on these remains suggest their burial near the place of their growth. Other organic remains consist of bones of mammals and other vertebrates, molds of fresh-water gastropods and rarely pelecypods, and others.

The Ogallala was deposited upon slightly tilted and truncated beds of Cretaceous and Permian age. There is a distinct overlap of Ogallala in the eastern area of outcrop. The bulk of the formation seems to have been deposited by repeated floods, each leaving a mantle of practically unsorted mountain debris brought from the eastern slopes of the Rocky Mountains. Some of the most prominent benches of pre-Ogallala topography served as natural barriers and checked the distribution of the Ogallala flood deposits in the east.

It seems that tilting caused the steeper eastern slope of the Rocky Mountain piedmont of pre-Ogallala time to change to more gentle grade, upon which there began the deposition of the Ogallala. The broad mantling of the area with mountain debris gradually leveled the relief, and at the end of Ogallala time a very broad but shallow lake or chain of lakes originated, along the shores of which algal limestone was precipitated. A reverse tilting of the area caused renewed erosion of the area. (*Author's abstract.*)

Discussed by Messrs. RUBEY, GILLULY, and GOLDMAN.

W. H. BRADLEY and T. B. NOLAN, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

National Bureau of Standards.—The axe of economy cut into the scientific work of the National Bureau of Standards, when some 380 of the staff were dismissed or "furloughed for an indefinite period" at the beginning of the new fiscal year. Severe curtailments of funds necessitated the wiping out of one whole part of the Bureau—the commercial standards group—and the reduction of activities throughout the entire plant.

The Altitude Laboratory stands idle for lack of funds, and the type testing of aeronautic engines has been discontinued. Research on radio and lighting aids to aviation has been brought to a standstill because the funds previously transferred from the Aeronautics Branch of the Department of Commerce are no longer available for this purpose. The Government's only laboratory for research on photographic emulsions is abolished and the experts there dismissed. Research on making of levulose from artichokes is abandoned.

Director Briggs hopes to obtain funds from the huge sums appropriated for public works, to cover the cost of testing at the Bureau the materials that will be used in the public works program. If he does, it may mean that some of the staff will be restored for this work. He also hopes that some of the scientists let out there may be placed in some of the new agencies where their special training and experience can be utilized in the recovery program.

U. S. Geological Survey.—Slashing of funds for scientific work has meant the loss to the U. S. Geological Survey of a galaxy of scientists of national and international reputation. Altogether about 150 persons were dismissed. Some of these were men who had been in the service for more than 30 years. Those leaving include: Dr. ARTHUR KEITH, treasurer of the National Academy of Sciences, and representative of the United States at many international scientific meetings; GEORGE STEIGER, expert on rocks, ores and minerals: FRANK CATHCART CALKINS, C. E. VAN ORSTRAND, Dr. NELSON HORATIO DARTON, Dr. ARTHUR COE SPENCER, LOUIS M. PRINDLE, Dr. CHARLES BUTTS, Dr. GEORGE BURR RICHARDSON, and ARTHUR JAMES COLLIER.

U. S. Bureau of Mines.—About one-fourth of the personnel of the U. S. Bureau of Mines were lost to the service because of the drastic cuts in funds available for the scientific and technical work of this Bureau. Of the \$1,514,300 appropriated by Congress, only \$1,100,000 has been allotted to the Bureau for the coming fiscal year. This means a reduction of 27 per cent below the appropriated amount.

All field offices are affected and some will have to be abolished. About 200 employees are dismissed. The health division is being abandoned, and officers assigned from the U. S. Public Health Service returned to the Service. The helium division is being merged with the petroleum and natural gas division.

St. Elizabeth's Hospital.—Application of diathermy in the treatment of general paralysis was found to be unsuccessful in a trial of the method at St. Elizabeth's Hospital. The results have been published in the Journal of the American Medical Association for June 3, 1933.

The first American textbook on Neuropathology, by Dr. WALTER FREEMAN, was published by Saunders & Co.

The confirmation of Kretschmer's ideas of the relationship between physique and mental reaction type was reported before the American College of Physicians at Montreal in February by Dr. WALTER FREEMAN. Studies were also reported upon the relationship between physical type and disease susceptibility, and it was shown that there was, on the whole, a somewhat more marked relationship between mental reactions and disease susceptibility than betweeen body build and disease susceptibility.

A detailed study on the weight of the endocrine glands in relation to body weight and stature has been carried out on some 1,200 cases, and interesting differences have been found among the sexes and races.

Perfection of methods for making reliable colloidal gold, with a study of its physical chemistry in relation to spinal fluid is an outstanding contribution of Dr. WINIFRED ASHBY.

Dr. KARL LANGENSTRASS has demonstrated that experimental catatonia in animals may be interrupted by a variety of drugs, and he is applying this knowledge to the interruption of the catatonic state in certain patients.

National Park Service.—The model of Mount Rainier, 9 feet high by 20 feet wide, modeled true to perspective, which is on display in the Government Building at the Century of Progress in Chicago, is attracting large crowds of visitors. There are a number of log benches cut from Ponderosa pine logs nearly four feet in diameter. These benches afford the visitor an opportunity to rest and view the Mount Rainier model leisurely.

Public Health Service.—At the meeting of the American Medical Association held in Milwaukee, Wis., June 12 to 16, a silver medal was awarded to the exhibit of Passed Assistant Surgeon L. F. BADGER in recognition of his original work and excellence of presentation of the exhibit submitted by him dealing with typhus fever and Rocky Mountain spotted fever, eastern type.

On June 22, 1933, Yale University conferred the degree of Doctor of Laws on Surgeon General HUGH S. CUMMING of the Public Health Service in recognition of his distinguished leadership in public health.

U. S. Weather Bureau.—As part of the Weather Bureau's program in connection with the International Polar Year, August 1932–August 1933, upper-air observations by means of airplanes are being made at Fairbanks, Alaska, on certain international days each month. The meteorograph which is attached to the airplane records temperatures, pressure and humidity to a height of five kilometers.

Observations are also being made at that station with radio-meteorographs attached to sounding-balloons, since the ordinary type of meteorograph would be useless there on account of the improbability that the instruments would be found and returned. Only a few such observations have as yet been made, but the results appear quite satisfactory, and the method gives much promise of coming into general use, especially in sparsely settled regions.

Fishery Investigation in Mississippi.—Dr. SAMUEL F. HILDEBRAND, Senior Ichthyologist of the United States Bureau of Fisheries, has recently returned from making an investigation of the fisheries of Mississippi. Mississippi's new State Game and Fish Commission having a very thorough appreciation of the necessity for accurate scientific information in formulating regulatory

measures for the conservation of the fisheries resources, sometime ago requested the U. S. Bureau of Fisheries to assign one of its biologists to make a general survey of the principal waters of the state, with the view of determining the status of the fisheries, and to study the life history of the various species of fishes, principally with respect to their spawning time and spawning habits. The bureau was glad to comply with this request and detailed Dr. Hildebrand to make the investigation.

Dr. Hildebrand visited the Pascagoula River system in southeastern Mississippi, the upper Pearl River system and several points in the Delta. He found the fisheries in the Pascagoula system in general in satisfactory condition. Except near the larger cities, game fish appeared to be plentiful, and according to commercial fishermen no diminution of the so-called "gross" or "commercial" species has been noticed.

No commercial fishing was being carried on in the upper Pearl River during Dr. Hildebrand's visit. The natural conditions in this section have been considerably disturbed through deforestation and drainage which together with rather persistent fishing, have tended to reduce the abundance of fish. The region is well adapted to the establishment of artificial bodies of water, that is, fish ponds and lakes. Several such waters already exist, and provisions for others are being made.

The most extensive fishing waters of the state occur in the Delta, where important commercial fisheries, as well as much angling for sport is carried on throughout most of the year. Although the periodical floods in the Delta no doubt are generally detrimental to spawning of some species at least, they do serve by their widespread nature to restock more or less depleted waters. On the other hand, when the waters recede almost countless young and sometimes mature fish become stranded and perish. Flood conditions have prevailed for several months this year, and many temporary waters with millions of fish will be left when the waters recede. It is understood, however, that the Game and Fish Commission will carry on an active fish rescue work at the appropriate time.

Dr. Hildebrand is now in Washington studying the data and the specimens collected so that he can submit a detailed report setting forth his findings and recommendations.

Scientific Unemployment.—Unemployment among research scientists, which threatens to become worse, is causing concern to responsible heads of research and research-coordinating institutions. While as yet only preliminary surveys have been made, these disclose the situation as exceedingly serious. A thousand chemists and over 2,500 engineers are reported as being out of work in New York City alone. A survey of the industrial field by Dr. Clarence J. West and Miss Callie Hull of the National Research Council indicates that since 1930 over 12,000 scientists have been released from the laboratories of industrial firms. A telegraphic inquiry addressed by Science Service to 25 of the leading universities of the United States gives as preliminary results: operating budgets reduced by about 20 per cent in 1933–34 as compared with 1932–33, research budgets reduced by varying amounts up to as much as fifty per cent, material reductions in both teaching and research personnel, and no employment in sight for a considerable proportion of the new Ph.D.'s. Efforts by various "economy" organizations have been aimed with especial vigor at scientific research conducted by the various departments of the federal government, presumably as being "safe" from political repercussions. The outcome of these drives is still in doubt,

though there is no doubt but that government research will have to undergo considerable curtailment at least for the immediate future.

News Briefs

Dr. Isaiah Bowman, director of the American Geographical Society of New York, has been elected chairman of the National Research Council, succeeding Dr. W. H. Howell. Dr. Bowman will devote half of his time to his new office. Dr. Howell, who accepted the chairmanship for a year during a period of reorganization of the Council, will continue his interrupted researches in physiology.

The Smithsonian Institution has just received seven mummies from a cave in Texas, preserved apparently by the natural dryness there. They are to receive intensive study by Dr. Frank Setzler of the Smithsonian.

Funds for the U. S. Department of Agriculture were reduced to a sum about 22 million dollars below the amount available last year. The Department will be allowed to draw only $60,000,000 in place of the $75,000,000 appropriated by Congress.

Experts on submarine air purification, Frank M. Hobson of the Navy Department and Dr. Parry Borgstrom, of the Naval Research Laboratory, cooperated with aeronautic experts in planning the gondola of the balloon for the flight from the Century of Progress Exposition grounds into upper regions of the earth's atmosphere. The air in the stratosphere gondola, as in the undersea vessel, must be kept in good breathing condition regardless of pressures and temperatures outside. Excessive moisture and noxious gases must be eliminated.

Thorianite, an extremely rare mineral, has been discovered in eastern Pennsylvania, Dr. Roger C. Wells, of the U. S. Geological Survey reported to the American Association for the Advancement of Science.

The pitchblende, radium-containing mineral, recently discovered in northern Canada is approximately 1,375 million years old, Dr. John Putnam Marble reported to the Century of Progress meeting of the American Association for the Advancement of Science. The measurement made by Dr. Marble in the laboratories of the U. S. Geological Survey, depended on the uranium-lead ratio in the ore.

A set of instruments which might be called electric gages were developed for use in making precise measurements of the dimensions of articles of compressible rubber. They are the work of W. L. Holt of the National Bureau of Standards.

A method of freeing tomato seeds from bacterial canker, by fermenting the pulp until the seeds drop out, was reported by H. L. Blood of the U. S. Department of Agriculture.

A new office of the National Research Council, that of honorary vice-chairman, is to be filled by Dr. William H. Welch, of the Johns Hopkins University, the "dean of American medicine."

Eel grass, valuable food plant for wild fowl, is apparently threatened with extinction, a study just completed by Clarence Cottam of the U. S. Biological Survey indicates.

The U. S. Naval Observatory has just issued a catalog of over 10,000 stars, the positions of which were determined from observations recently made at the Observatory.

Personal Items

Dr. Paul Bartsch, of the U. S. National Museum gave a radio talk under the auspices of Science Service, over the network of the Columbia Broadcasting system, describing the life in ocean deeps.

Robert Y. Stuart, Chief of the U. S. Forest Service, was awarded the degree of Doctor of Science from Dickinson College, at Carlisle, Pa., June 12. Major Stuart was graduated from Dickinson College with an A.B. degree in 1903, and an A.M. degree in 1906.

Dr. H. L. Curtis, of the National Bureau of Standards, read a paper before the meeting of the American Section of the International Physics Union in Chicago, in which he stressed the need for new and more accurate determinations of the value for electrical units.

Dr. Philip B. Matz, of the U. S. Veterans' Administration, delivered an address at the meeting of the American Medical Association in Milwaukee in which he called gas warfare one of the most humane of modern weapons.

Dr. Paul Hanly Furfey, of Catholic University, attended the Conference on Research in Child Development of the National Research Council, held in Chicago. He told the meeting that over-solicitousness on the part of parents may make children "young for their age."

O. H. Gish was appointed Assistant Director of the Department of Terrestrial Magnetism effective July 1, 1933.

L. V. Berkner, formerly at the U. S. Bureau of Standards, has received a temporary appointment as Associate Physicist at the Department of Terrestrial Magnetism, where he will be engaged on the investigation of the ionosphere by radio methods.

The University of Cincinnati conferred an honorary degree of doctor of science on J. A. Fleming, Acting Director of the Department of Terrestrial Magnetism, on June 10, 1933.

Horace M. Albright resigned as Director of the National Park Service. Arno B. Cammerer, formerly Associate Director, succeeds Mr. Albright as Director.

Assistant Director Harold C. Bryant of the National Park Service left Washington the latter part of June. He plans to visit a number of the national parks and monuments and will return to Washington in early September.

Geologist Earl A. Trager of the Washington Office of the National Park Service will leave Washington shortly for a trip to the Cades Cove region in the western part of the Great Smoky Mountains National Park. Mr. Tager will determine whether or not a lake once existed at Cades Cove.

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Vol. 23 September 15, 1933 No. 9

PHYSICS.—*The seismic receiver.*[1] F. W. Sohon, S. J., Georgetown University. (Communicated by F. G. Brickwedde.)

The radio receiver has grown familiar to us as a household article and while it is really more complicated than the seismograph, a comparison of the two may serve to dispel some of the mystery associated with the receiver of seismic manifestations. Both are harbingers of distant tidings, one indulging in phonetics and the other speaking in idiograms; and while at first sight one might hesitate about pursuing the analogy too closely, knowing that all comparisons limp, still on further reflection one easily appreciates that the resemblance is far from superficial.

The first thought that strikes us is that both the seismic receiver and the radio receiver are devices actuated by wave motions. The radio receiver responds to waves set up in the ether, or if there is no ether, it responds to the equivalent of what we have been calling waves in the ether that are set up by a transmitting station. The seismic receiver takes cognizance of waves set up in the interior of the earth and on its surface by the earthquake shock itself which does its own transmitting. There are differences, of course, and we might mention the fact that the ether waves are transverse, while the earth transmits both longitudinal and transverse waves, both pushing and shaking phenomena. We shall not stop to point out analogies between the two kinds of wave motion, but merely mention the fact that the path of the seismic message is worked out by geometrical optics, that we have reflection and refraction and dispersion of seismic waves in the interior of the earth, and that if the seismic problem is complicated by surfaces of discontinuity beneath the surface of the earth, the radio problem is not made any simpler by the Heaviside layer above the earth's surface. But let us put all this aside as more or less obvious now that it has been called to our attention, for we are more interested in the instruments themselves.

[1] Paper delivered before the Philosophical Society of Washington, February 11, 1933. Received February 16, 1933.

Apart from rectifying and amplifying devices and other accessories, the heart of the radio receiver is its oscillating system, and when we understand the oscillating system we stand a fair chance to understand something about the radio receiver. The oscillating device consists of three essential elements, an inductance, a capacity, and resistance, or as we might say, a sustaining element, a storing element, and a smothering element. When we have an axcess of electrons on one plate of the condenser and a deficiency on the other, the situation is relieved by a flow of electrons through the circuit. The office of the inductance is to sustain the flow, and on account of this action, the flow does not stop when things are just balanced, but continues until the sustaining power of the inductance is overcome by the back pressure due to the excess of electrons on the other side of the condenser. Then the process reverses. A seismograph is a kind of pendulum in most cases, and instead of an inductance the sustaining element is the inertia of the swinging system. The storing element which takes the place of the condenser consists in the rise of the weight against the force of gravity, in most cases, or it may consist in the stretching of a spring or the twisting of a wire. When the moving system has been displaced from the equilibrium point, then gravity, or the recoil of a spring, or the torque of a wire pulls the system back. But just as the motion of the electrons was sustained by the action of the inductance, so the motion of the seismograph is sustained by the inertia of the moving parts. The weight is thus rushed past the point of equilibrium until the momentum is overcome and the motion arrested by the operation of the restoring forces on the other side. In the radio receiver, an oscillation once set up would never cease were it not for the resistance of the circuit that dissipates the energy in the form of heat. The seismograph would never come to rest were it not for the smothering effect of friction or damping devices that more or less quickly destroy the motion of the boom.

But the analogy between the radio receiver and the seismic receiver does not stop with these fundamental structural details, but extends itself to functional considerations. Every oscillating system has a natural frequency determined by the relation between the sustaining, the storing, and the smothering elements. When you turn the dial of your radio receiver, by adjusting the relation between inductance and capacity, you change the frequency of the circuit. As you approach the proper adjustment for a station, the output is at first faint, but swells up rapidly to a maximum, and then as you continue to turn, it becomes faint again. With the seismograph we do

not stay at hand to tune it all the time, so the same effect is produced as the period of the seismograph remains fixed and that of the incoming wave varies, mostly out of tune. The magnification of a seismograph varies in exactly the same way that the amplification of a radio set varies when it is not exactly in tune, and the greater the discrepancy between the wave length of the instrument and the length of the incoming wave, the smaller the magnification. That is why it is necessary for a correct interpretation of a seismogram, to measure the period of each wave, find the magnification corresponding to its wave length from tables or curves and then to correct the trace amplitude for the variable magnification. For the same reason the question of the choice of a proper period for a seismograph is a long story, which can not be told here.

This variable magnification which gives so much trouble in a seismograph is a great virtue in the tuned stages of a radio set and every effort is made to encourage it. Hence the reduction in the size of the antenna, the use of the indoor antenna, loose couplings. The idea is to get as narrow a band of frequencies as possible. With the seismograph we try to get as tight a coupling as possible, a concrete pier going down to bed rock, making the frame of the machine as nearly as possible a part of the earth itself. Broadening the band of frequencies to which an oscillating system is sensitive or in other words decreasing the selectivity is possible if we increase the smothering action, increase the resistance of the radio circuit, increase the damping of the seismograph. The effect of this procedure is twofold. The band of frequencies through which a response is obtained is broadened. This represents a loss in selectivity, but a gain for sensitivity except for waves that happen to be in tune. At the same time a general flattening of the magnification curve takes place, reducing the magnification. The flattening of the magnification curve is a great advantage to the seismologist as we shall see presently, though the loss in magnification is a disadvantage. In the earlier instruments before the introduction of optical recording this was a heavy sacrifice. Hence the damping was kept very low. Even then, to overcome the friction of the needle point plowing its way through a film of soot on a highly glossed paper, the mass of the instrument had to be made very great if much magnification was desired. Now with the perfected methods of optical registration, we can afford to push the damping up until the system just ceases to oscillate.

In the radio set on the other hand it is selectivity and not sensitivity that is desired. Low resistance wire is used. Braided wire is

used. Connections are made as short as possible and are kept tight by soldering. It is all to make the set as selective as possible, to make it sensitive to as narrow a band as possible. Of course one can go too far even in a radio set, and spoil the modulation by shaving the band too close. But it will be understood that we are here merely speaking of tendencies.

In spite of all efforts to the contrary a certain amount of selectivity is obtained in a seismograph. The slow speed of the paper, which is as low as 6 mm. per minute on some instruments, and is as high as 60 on others, means that vibrations that are too quick will be lost due to the thickness of the trace or to the overlapping of images where optical recording is employed. You have something similar to this in the limited sensitiveness of the diaphragm of your ear phone or the armature of your loud speaker. According to Galitzin, selectivity of this kind is more or less of a virtue, because the quick vibrations that would be recorded would for the most part be those due to machinery and would be evidence of industrial rather than seismic activity. Since his time, however, we have begun to realize that while the long periods characterize the waves from the distant sources that have come through the heavier, deeper rocks, the near-by earthquakes send their messages in quicker vibrations through the lighter rocks near the surface. Hence to record close earthquakes one must be ready to make something of shorter periods than Galitzin was interested in. Again if we are interested in accelerations instead of displacements the shorter period instrument gives a better picture. But no radio set records when it is so far out of tune, so we pass these questions and many others with the acknowledgment that things are not quite as simple as we are trying to make them out to be.

Our modern radio sets secure an increase in magnification by connecting the first oscillating system to another through a transformer. In these sets there is more than one circuit to be tuned but we have an increase in amplification with an increase in selectivity. Galitzin, to secure the same end does a similar thing, though he does not regard the increased selectivity as an advantage. Instead of securing additional magnification through a system of levers, Galitzin has placed a set of coils on the end of the boom in a magnetic field maintained by permanent magnets attached to the frame of the seismograph. If the boom of the seismograph moves, an electromotive force is produced in the coils, and this serves to operate a sensitive galvanometer. The record is made optically by reflecting a beam of light from the mirror of the galvanometer to a drum with sensitive bromide paper. In the

transformer of the radio set we have two electric circuits linked together by a magnetic circuit. In the Galitzin arrangement we find that we have two magnetic circuits, one at the pendulum, one in the galvanometer, linked together by a single electric circuit. So we see that the Galitzin scheme for obtaining an increased response for a given input signal is not so different from the radio scheme after all. A precisely similar statement holds for the Wenner instrument.

The resemblance between a seismograph and a radio set extends even to the defects. The howling and squawking of a radio set is the distortion produced by the internal oscillation of the set. It is precisely the distortion produced by the proper motion of the seismograph that creates the great problem for the makers of those instruments. One source of the distortion is the fact that the magnification curve is not flat. There are other sources, and these have also their electrical analogies. And just as radio manufacturers quite justly insist that purity of tone is the greatest factor in deciding between instruments or another, so in seismographs the question of the purity of the record is of importance, and there has been much said on the point by designers of different types of seismographs, even though we have had to sacrifice our ideals in this regard in order to get a practical working instrument.

GEOLOGY.—*Bentonite in northern Virginia.*[1] R. R. ROSENKRANS, Pennsylvania State College. (Communicated by JOHN B. REESIDE, JR.)

It is now a little more than a decade since bentonite of middle Ordovician age was first reported from strata of the Appalachian province. Many additional occurrences have been discovered in recent years and the attention of the stratigrapher has been focused upon the possibilities of using these bentonite beds as key horizons in close stratigraphic correlation.

The idea is not new, though as yet extensive application of the correlation of bentonite beds to the solution of stratigraphic problems, except in one or two places, has not been made. The value of a bentonite bed for such work lies, of course, in the fact that it represents an ash fall which occurred within a very brief interval of time. Where such a bentonite bed is interstratified with unquestionable marine strata, the immediately subjacent strata must be essentially contem-

[1] Received April 23, 1933.

poraneous. If a single bentonite bed, or better still a series of them, can be recognized in a series of sections, the contemporaneity of these sections is practically established.

Within the past year and a half through the work of the writer[2] and through the work of Whitcomb[3] it has been established that a series of six thin bentonite beds occur in the basal portion of the Salona formation (late Black River or early Trenton age) of central Pennsylvania. These beds have been carefully traced throughout the

Table 1.—Generalized Section of the Basal Salona of Central Pennsylvania

	Feet	Inches
Salona formation:		
Shales, black, calcareous, slaty, interbedded with impure, shaly, dense, black limestones		
Bentonite (No. 5)	0	6
Shales, black, calcareous, slaty and impure limestones carrying *Homalonotus trentonensis* in upper portion	65	
Bentonite (No. 4)	0	3
Limestones, shaly, impure, thin-bedded	35	
Bentonite (No. 3)	0	8
Limestones, shaly, impure, thin-bedded	15	
Bentonite (No. 2)	0	6
Limestone, black, impure, with upper two inches silicified (very cherty) and with upper surface characteristically checked, yellowed, and covered with fossil fragments, frequently *Cryptolithus*.	1	3
Bentonite (No. 1)	0	1
Limestone, thin-bedded, shaly, black	15	
Bentonite (No. 0)	0	1
Limestone, dense, black, non-fossiliferous	0	9
Rodman formation:		
Limestone, cobbly, impure, coarsely crystalline, crinoidal	2	
Limestone, crinoidal, gray, coarsely crystalline		

entire middle Ordovician province of central Pennsylvania. As a result of this detailed work much light has been shed on certain stratigraphic problems of the area. One of the questions, however, that has been of much concern to the student of Appalachian stratigraphy has been that of the exact relationship of the central Pennsylvania middle Ordovician formations to those of neighboring areas.

Having successfully traced a series of bentonite beds throughout the Pennsylvania area the writer directed his attention to the possibility of recognizing these beds in adjacent areas. As it has long been postulated that the source of the middle Ordovician volcanic ash was in the southeastern portion of the United States, possibly in central

[2] Rosenkrans, R. R. Master's Thesis, (unpublished), Pennsylvania State College, 1933.

[3] Whitcomb, L. *Correlation by Ordovician bentonite.* Journ. Geol. **15**: 522–534. 1932.

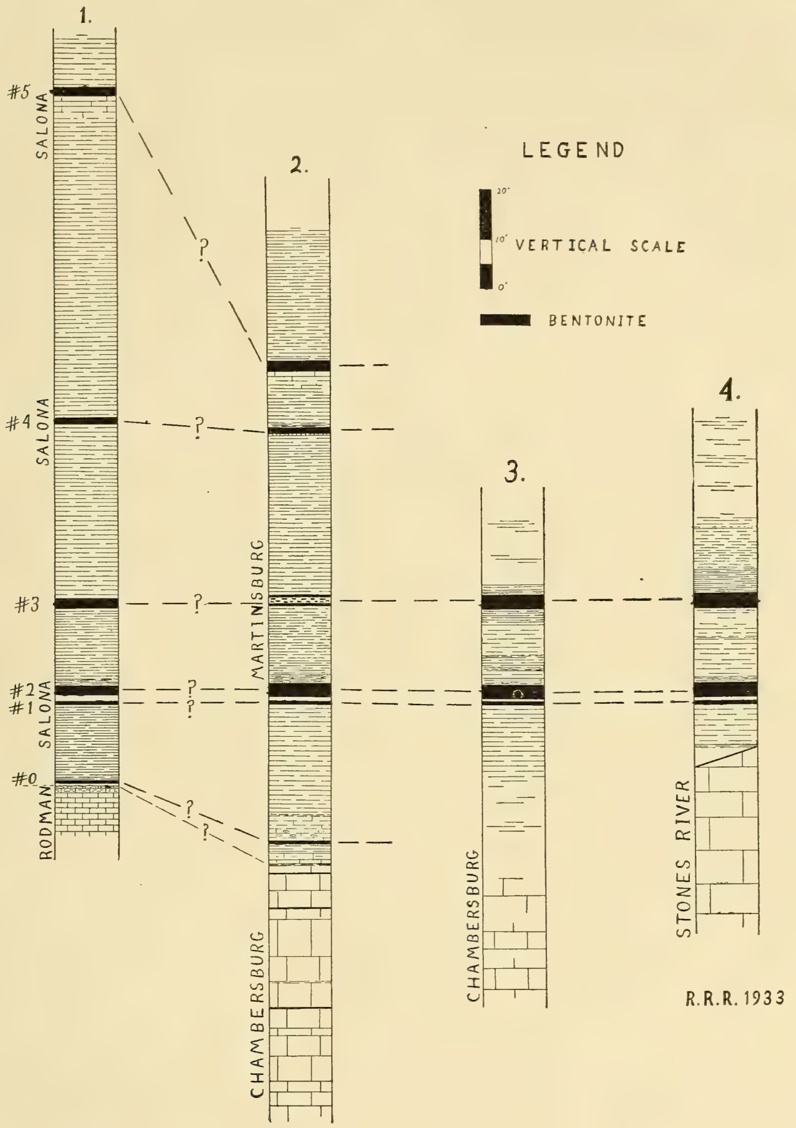


Fig. 1.—Correlation of the basal Martinsburg bentonites in northern Virginia and the suggested correlation of these beds with the bentonites at the base of the Salona formation in central Pennsylvania. 1. Generalized columnar section of the basal Salona of central Pennsylvania. 2. Section as exposed along highway No. 11 approximately one mile southwest of Strasburg, Virginia. 3. Section at Woodstock, Virginia. 4. Section near Mauzy, Virginia. Note that the thickness of the bentonite beds is greatly exaggerated. Note the persistence of the group of beds consisting of bentonites No. 1, No. 2, and the intervening strata. This group was persistent throughout the entire central Pennsylvania Middle Ordovician province.

or southern Virginia,[4] it seemed quite likely that the above-noted series of bentonite beds might be recognized in that state, though they might perhaps be somewhat thicker due to greater proximity to the source of the ash.

In April 1932 the writer examined the Ordivician section at Strasburg, Virginia and was decidedly impressed by the similarity of this section to those in central Pennsylvania. During the latter part of June and again in September he revisited this section and traced certain of the bentonite beds occurring in the basal Martinsburg formation southward for a distance of forty miles along the strike. In October the Strasburg section was again visited in company with Dr. Whitcomb of Lehigh who was likewise impressed by the similarity of this to the Pennsylvania sections of which he has written.[5]

It seems advisable at this time to describe the occurrence of these bentonite beds at Strasburg, Woodstock, and near Mauzy, and in particular to suggest the correlation of these beds with those traced in central Pennsylvania. In Fig. 1 is presented graphically this suggested correlation of the Pennsylvania bentonite beds with those seen at Strasburg, Woodstock, and near Mauzy in Virginia.

SECTION AT STRASBURG, VIRGINIA

In a roadcut approximately one quarter mile beyond the point where the Virginia state highway No. 11 crosses Tumbling Run, and approximately one mile southwest of Strasburg, is exposed the following excellent section of the basal Martinsburg formation and the upper beds of the subjacent Chambersburg limestone. The beds at this point strike N. 30 E. and dip 35 SE.

Additional study of nearby outcrops seems to indicate the occurrence of at least two additional thin beds of bentonite above that designated as No. 5 (?). A one-inch bed at 37 feet and a 2-inch bed at 61 feet above No. 5 (?) were observed. No central Pennsylvania equivalents of these beds have been recognized, or else one of these is the southward extension of the No. 5 bed seen in Pennsylvania and the bed designated as No. 5 (?) in this paper has not been recognized in the northern sections.

Along the road leading from the main highway to Fisher's Hill, and along the banks of Tumbling Run there is exposed a complete section of the Chambersburg limestone. At least four beds of bentonite occur

[4] Giles, A. W. Journ. Geol. **35**: 527–541. 1927. Gives summary of statements by W. A. Nelson as to location of vent supplying the middle Ordovician volcanic ash.
[5] Whitcomb, L. Op. cit., pp. 522–534.

TABLE 2—SECTION OF BASAL PART OF MARTINSBURG FORMATION AND UPPER PART OF CHAMBERSBURG LIMESTONE

	Feet	Inches
Martinsburg formation:		
Shale, slaty, calcareous, brown to black		
Covered interval	50	
Shale, calcareous, slaty, weathers brown	28	
Bentonite (No. 5?)	0	6
Shale, calcareous, slaty, less calcareous at base and containing abundant graptolites (*Diplograptus* sp.) at 3 feet	9	
Shale, very blocky	1	
Bentonite (No. 4?)	0	3
Limestone, light gray, coarse, very fossiliferous, seems to be composed entirely of the remains of a small brachiopod	0	3
Shale	32	
Bentonite and shale, zone consisting of a 1-inch bentonite bed resting on an 8 inch bed of bentonitic shale from which it is separated by a thin layer of slickensided calcite, and this bed in turn resting on a thin layer of bentonite (No. 3?)	0	10
Shale, earthy, brown-weathering, abundant remains of *Cryptolithus* and some large *Lingula* at 8 feet	14	
Shale, black, blocky	1	
Bentonite, massive (No. 2 ?)	0	10
Shale, massive bed, very fossiliferous, upper portion silicified (cherty) and with the upper surface characteristically checked, yellowed, and with numerous fossil fragments including *Cryptolithus*. At 6 inches this bed seems to be composed entirely of the remains of a large *Asaphid*	0	9
Shale, thin, chocolate colored	0	2
Bentonite (No. 1 ?)	0	3
Shale, calcareous, light gray on weathered surface, earthy, very fossiliferous, with *Christiania* abundant and occasional *Echinosphaerites*	22	
Shale, thin, brown, weathers to brown mud	0	3
Shale, calcareous, cobbly, with at least three zones of large nodular limestone concretions	5	
Bentonite (No. 0 ?)	0	2
Shale, calcareous, very cobbly, bluish-gray	2	4
Chambersburg limestone:		
Limestone, massive, dense, thin-weathering, bluish	1	3
Limestone, bluish and cobbly	0	5.5
Shale, gray, thin	0	4
Limestone, massive, bluish	1	3
Bentonite or bentonitic shale, a thin bed largely shale	0	1
Limestone, massive, bluish, very few fossils	6	2
Bentonite or bentonitic shale	0	1
Limestone, massive, bluish	18	9
Shale, yellowish and possibly somewhat bentonitic	0	2
Limestone, massive, bluish-gray, with *Nidulites* scarce in upper beds but becoming more abundant in lower beds		

near, or a little below, the base of this limestone. One of these is 9 inches thick, and one is 6 inches thick. Each of the other two is only one inch thick. Whether these have any central Pennsylvania equivalents or not is at present unknown, though several thin bentonite beds occur in the Carlim of that area.

Along the bed of a small creek at the east edge of Woodstock is exposed a partial section of the basal Martinsburg and the upper beds of the subjacent Chambersburg. At this locality the beds No. 1 (?), No. 2 (?), and No. 3 (?) are exposed. Bed No. 0 (?) is probably present though this portion of the section is covered. A few feet below this horizon the thick bluish limestone beds of the upper Chambersburg are exposed.

At a point seven miles south and a quarter mile east of New Market a partial section of the basal Martinsburg is exposed. Bentonite beds No. 1 (?), No. 2 (?), and No. 3 (?) are exposed here. Nine feet beneath No. 1 (?) the basal Martinsburg has been faulted against massive, dove-colored strata of Stones River age, the intervening Chambersburg beds having been cut out.

In each of the three above mentioned sections occur the group of beds consisting of the thick bentonite No. 2 (?), the thinner bentonite No. 1 (?), and the intervening 12–20 inches of shale, the upper portion of which has been silicified. The surface immediately beneath bentonite bed No. 2 (?) is characteristically checked, yellowed, and covered with fragmentary fossils among which are fragments of *Cryptolithus.* This group of beds is apparently the same as that which served as a readily recognizable datum in tracing the bentonites of central Pennsylvania. If it is not the same group, then this is a most remarkable coincidence. The approximate equivalence in age of the containing strata as established on paleontological grounds, the lithologic similarity of these strata, and the additional occurrence of bentonite beds No. 0 (?), No. 3 (?), No. 4 (?), and No. 5 (?) strengthen the suggested correlation of these sections with the basal Salona formation of central Pennsylvania.

In this paper which contains only a brief statement of the occurrence and correlation of the bentonite beds in the basal Martinsburg of northern Virginia, and a suggested correlation with the beds of central Pennsylvania, it is not necessary to discuss the petrography of these bentonites. However, the writer has studied material from each of the outcrops cited, and has established by petrographic methods that it is bentonite.

This correlation of the basal Salona of Pennsylvania with the basal

Martinsburg of northern Virginia, if substantiated by further detailed work which has been undertaken by the writer, will prove a distinct step toward clarifying the relations of the middle Ordovician of central Pennsylvania to the neighboring Ordovician terranes.[6]

[6] The writer is indebted to Dr. Lawrence Whitcomb of Lehigh University, to Dr Josiah Bridge of the U. S. Geological Survey, and to Dr. E. O. Ulrich who have kindly read the manuscript of this paper and have offered many helpful suggestions.

BIOCHEMISTRY.—*The evaluation of the Rupp-Schied-Thiel method as a test for thiocyanate in the urine.*[1] M. X. SULLIVAN and W. C. HESS, Georgetown University.

The iodometric method for thiocyanate devised by Rupp and Schied (1) and improved by Thiel (2) has been used considerably in biochemical work. Gies and collaborators (3), (4) found it satisfactory in their extensive study of thiocyanate in the mammalian body. Saxl (5) applied it to the urine in cancer and concluded that quantitatively thiocyanate is increased in the urine in cancer with values appreciably higher than normal and higher than found in any other disease. Sullivan and Dawson (6) made use of the method in their study of pellagra. In the pellagra work comparative values between the acute and cured conditions were sought and no attempt was made to determine the degree of specificity of the Rupp-Schied-Thiel reaction for thiocyanate when applied to saliva or urine. Recently, Sullivan and Hess (7) used the method in a study of the urine of various pathological conditions, cancer in particular. In their work a number of cases of marked cancer involvement showed high apparent thiocyanate as found by Saxl but other cases of cancer marked enough to lead to death were within normal limits and sometimes below normal. They concluded that the excretion of material behaving like thiocyanate is not necessarily increased in cancer.

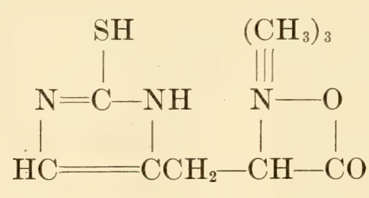
Sullivan and Hess found exceedingly high thiocyanate values in multiple myeloma (malignancy of the bone marrow) and were led to the conclusion that other substances than thiocyanate were possibly being measured. From theoretical grounds, also, it seemed that the specificity of the Rupp-Schied-Thiel procedure might be questionable when applied to a complex such as urine. Accordingly, a critical study was made of the method. As will presently be shown, other substances in urine were found to react like thiocyanate in the Rupp-Schied-Thiel procedure, that is, they are precipitated by silver nitrate in the

[1] This work was supported by a Research Grant from the Chemical Foundation. Received June 9, 1933.

presence of dilute nitric acid and the precipitate reacts with iodine under the same condition that thiocyanate does in a medium made alkaline with sodium bicarbonate and containing potassium iodide. The details of the Rupp-Schied-Thiel procedure as applied to urine are given by Saxl (5) and with slight modification by Sullivan and Dawson (6) and Sullivan and Hess (7).

In testing the degree of specificity of the Rupp-Schied-Thiel reaction, tests were made on urinary pigment, creatine and creatinine, taurine, glyoxal, glutathione, uric acid, xanthine, guanine, and adenine, ergothioneine, urinary proteose, and oxyproteic acids. A normal urine freed to a high degree from pigment by Drabkin's (8) method gave 88 per cent as much thiocyanate-like material as before the extraction. Creatine and creatinine and taurine give no precipitate with silver nitrate in acid solutions and do not react with iodine in an alkaline medium. Glyoxal does precipitate with silver nitrate and takes up iodine; so if present (for the probability of which we offer no proof), it would interfere in the thiocyanate work. Neither oxidized nor reduced glutathione gives a precipitate with silver nitrate though they will use up iodine. Xanthine, guanine, and adenine are precipitated by silver nitrate but do not react with iodine in an alkaline medium in the procedure followed. Uric acid reacts with iodine in alkaline medium somewhat like thiocyanate, 10 mg. of uric acid are in fact equivalent to 4.47 mg. of KCNS. While uric acid in aqueous solution as the sodium salt is not readily precipitated by silver nitrate, sodium urate added to urine is in part precipitated by silver nitrate and is to some slight degree a positive interferer in the Rupp-Schied-Thiel reaction. The greatest interference apparently comes from other sources such as ergothioneine-like compounds and oxyproteic acids which are considered below.

Ergothioneine.—This compound isolated from blood by Benedict (9), Benedict, Newton, and Behre (10), Hunter and Eagles (11), (12), was found by Newton, Benedict, and Dakin (13) to be identical with the base ergothioneine isolated from ergot by Tanret (14), and shown by Barger and Ewins (15) to be the betaine of thiohistidine:



Having on hand a sample of ergothioneine isolated from blood, it was tested to see if it would react like thiocyanate in the Rupp-Schied-Thiel procedure. Five milligrams were dissolved in 25 cc. of water. This solution gave a gelatinous precipitate with silver nitrate. The precipitate was centrifuged, washed, and put through the thiocyanate procedure. It was found that 5 mg. of ergothioneine ($C_9H_{15}N_3SO_2 \cdot 2H_2O$) was the equivalent of 2.9 mg. of KCNS, or 1.763 mg. of HCNS.

Benedict, Newton, and Behre (10) showed that ergothioneine is precipitated by silver lactate in the presence of lactic acid as uric acid is but unlike uric acid is not freed from the silver compound by treatment with acid sodium chloride used in the Folin-Wu (16) method for uric acid. In their procedure the silver insoluble complex freed from uric acid and dissolved in sodium cyanide gives a blue color with the uric acid reagent and sodium hydroxide.

The Benedict (17) blood procedure was then applied to the urine. To 3 cc. of urine, Folin-Wu's acid silver lactate was added in slight excess. The mixture was centrifuged and the supernatant liquid decanted. The insoluble residue was washed by stirring with acid sodium chloride (10 per cent sodium chloride in 0.1 N hydrochloric acid) in 50 cc. lots, centrifuging and decanting until the washings no longer gave a color with the uric acid reagent.

The insoluble residue was put into solution with the minimum amount of 5 per cent sodium cyanide. To do this 6 cc. of the cyanide was usually required so the use of 6 cc. of cyanide was made a routine. To the solution in cyanide were added 1 cc. of the Folin-Marenzi (18) reagent and 1 cc. of N sodium hydroxide. The standard solution for comparison was 0.5 mg. of ergothioneine dissolved in 6 cc. of 5 per cent sodium cyanide and treated in the same manner as the unknown. As Behre and Benedict (17) in their study of blood give evidence of the presence of other material behaving like ergothioneine, the material judged to be present in urine is labeled ergothioneine-like. This ergothioneine-like material reacts like thiocyanate in the Rupp-Schied-Thiel method but is entirely distinct from thiocyanate. The latter is extracted to a large degree from the silver nitrate precipitate by acid sodium chloride and, more important still, does not react with the uric acid reagent as ergothioneine does.

In normal urine the amount of material reacting like ergothioneine excreted in 24 hours varied from 76 mg. to 154 mg. as judged by colorimetric comparison with the standard ergothioneine from blood. The average of 11 normals was 117 mg. for an average volume of 1311 cc.

or approximately 89.2 mg. per liter. In the Rupp-Schied-Thiel thiocyanate procedure this amount of ergothioneine-like material considered as ergothioneine would be the equivalent of 31.46 mg. of HCNS as 5 mg. of blood ergothioneine was found by us to be equivalent to 1.763 mg. of HCNS. The presence in the urine of substances comparable to ergothioneine makes work with the Rupp-Schied-Thiel method a questionable measure of thiocyanate. Attention was then given to the study of ergothioneine in urine. The details of the ergothioneine investigation, which by isolation methods prove the presence of at least some ergothioneine in urine, will be given in a subsequent paper.

Urinary proteose.—Oriel and Barber (19) isolated from urine material which they called urinary proteose. This they found the carrier of antigenic properties in allergic conditions. It occurs in normal urine but generally in much smaller amounts than in pathological urines and not accompanied by antigenic material.

In testing Oriel and Barber's claims, the so-called proteose was collected from a number of urines, normal and from allergic conditions. When put through the Rupp-Schied-Thiel procedure, (precipitation with silver nitrate and reaction with iodine etc.), 100 mg. of the combined crude proteose in 15 cc. of water and 2 cc. of 1 per cent nitric acid were found to have a thiocyanic acid equivalent of 2.736 mg. From normal urines with a single individual using the Oriel and Barber treatment there have been isolated on the average 400 mg. of crude proteose per liter. Accordingly, the proteose is more or less a positive interferer in the Rupp-Schied-Thiel thiocyanate method.

Oxyproteic acid.—Oxyproteic acids were isolated as barium salts following Pregl's (20) procedure. This complex is precipitated by silver nitrate and reacts with iodine as thiocyanate does. From normal urine, Pregl isolated more than 5 grams of the barium salt of oxyproteic acids per liter of urine. In the present work there was obtained 6.43 grams of the barium salt of oxyproteic acids per liter of urine or 122.2 grams from 19 liters. One hundred milligrams of this salt containing 28.61 per cent barium was equivalent in the Rupp-Schied-Thiel procedure to 1.2 mg. of KCNS so 5 grams would be equivalent to 60 mg. of KCNS or 36.5 mg. of HCNS.

When tested by the Benedict procedure for ergothioneine and by the Hunter (21) ergothioneine reaction both the proteose and the barium salt of oxyproteic acid were found free of ergothioneine. Conversely, neither the proteose nor oxyproteic acid interfere in the estimation of ergothioneine-like material. Both these compounds are pre-

cipitated by silver lactate but are washed out by the acid sodium chloride mixture in the same way that uric acid is.

In tests on individual urines it was found then that the thiocyanic acid value of the proteose and the oxyproteic acids was variable and

TABLE 1

Analysis of Normal Urine for Total Thiocyanate-like Material, Ergothioneine, Proteose, and Oxyproteic Acid.

Subject	Vol. cc.	Apparent HCNS mg.	Ergothioneine-like material calculated as ergothioneine mg.	Proteose mg.	Barium oxyproteic acids mg.
1 (H)	530	101.27	131.65	556	5.421
2 (S)	800	66.19	109.20	354	5.828
3 (I)	830	116.10	83.17	404	8.358
4 (W)	830	140.60	77.61	664	5.937

peculiar to each indivual. Accordingly, total apparent thiocyanate and the thiocyanate value of ergothioneine-like material, proteose, and barium oxyproteic acids were determined on 4 individual urines. The apparent thiocyanate was determined by the Rupp-Schied-Thiel procedure; the ergothioneine-like material by colorimetric comparison with blood ergothioneine in the Behre and Benedict procedure; then

TABLE 2

The Thiocyanate Equivalent of Ergothioneine-like Material, Proteose, and Barium-Oxyproteic Acids in the Rupp-Schied-Thiel Method for Thiocyanate.

Subject	Apparent HCNS	HCNS equivalent of			HCNS by difference
		Ergothioneine	Proteose	Ba oxyproteinates	
	mg.	mg.	mg.	mg.	mg.
1 (H)	101.27	46.43	9.31	21.27	24.26
2 (S)	66.19	38.51	5.23	11.48	10.87
3 (I)	116.10	29.33	4.77	42.82	39.18
4 (W)	140.60	27.37	13.08	46.93	53.22

proteose and the barium oxyproteic acid fraction by weighing air dried. The data obtained are given in Tables 1 and 2.

Inasmuch as the procedures of extraction employed do not extract all the proteose and oxyproteic acid from the urine, it is evident that the real thiocyanate content of a normal urine is small. It is indeed, smaller than given by difference in Table 2 as no data were obtained on the positive interference of uric acid in the Rupp-Schied-Thiel

thiocyanate method. It is certain, however, that the unmodified Rupp-Schied-Thiel iodometric method is not a measure of thiocyanate in the urine. Without comment on its applicability to extracts of blood and other tissue, it may be said that preliminary experiments indicate that the main material of the saliva reacting in the Rupp-Schied-Thiel procedure is thiocyanate.

The Munk method.—A method that has been employed for the estimation of thiocyanate is the Munk (22) gravimetric method. In this method the thiocyanate is precipitated by silver nitrate in the presence of dilute nitric acid and the silver precipitate is melted with sodium carbonate and potassium nitrate to convert the sulfur of the thiocyanate to sulfate. From the sulfur precipitated by barium chloride the thiocyanate is calculated. This method is likewise questionable when applied to urine because the silver nitrate precipitates other sulfur complexes than thiocyanate, among them ergothioneine-like material, proteose, and oxyproteic acid.

There is need of a more specific method for the determination of sulfocyanate in urine. Based on the observation that strong alcohol does not dissolve uric acid, ergothioneine, proteose, or the barium salt of oxyproteic acid whereas barium thiocyanate is soluble, a somewhat improved procedure has been employed as follows: An aliquot of urine, generally 50 cc., is treated with a saturated aqueous solution of barium hydroxide as long as a precipitate forms. The mixture is filtered and washed. The filtrate is brought to dryness on the water bath and is extracted with warm absolute alcohol and filtered. The procedure of evaporating, extracting with alcohol, and filtering is repeated. Then the alcohol is driven off, the residue dissolved in 25 cc. of water and the Rupp-Schied-Thiel procedure applied to the solution. Such a procedure has given a return of 97.2 per cent for potassium thiocyanate added to the urine and shows in urine amounts of thiocyanate very much smaller than the original Rupp-Schied-Thiel procedure applied to urine directly.

Using this procedure the amounts of thiocyanic acid found in the four urines of Table 2 become in fact, H, 14.2 mg.; S, 5.3 mg.; I, 17.6 mg.; and W, 25.5 mg.—values much lower than by difference as given in Table 2 and overwhelmingly lower than found by the unmodified Rupp-Schied-Thiel method.

SUMMARY

The Rupp-Schied-Thiel procedure applied directly to urine is not specific for thiocyanate in that it gives positive results with ergo-

thioneine-like material, with proteose, and with oxyproteic acid and to some degree with uric acid. A large amount of the apparent thiocyanate material in urines in both the Rupp-Schied-Thiel procedure and in the Munk gravimetric procedure is explainable by the presence in the urine of ergothioneine-like material and of oxyproteic acids. An improved procedure is given which excludes most if not all the interfering substances and shows in urine amounts of thiocyanate very much smaller than does the original Rupp-Schied-Thiel procedure applied to urine directly.

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PALEONTOLOGY.—*Mylodont (Ground Sloth) dermal ossicles from Colombia, South America.*[1] R. LEE COLLINS, Johns Hopkins University. (Communicated by E. W. BERRY.)

This paper reviews briefly some of the literature on dermal ossicles in the mylodont group of ground-sloths and describes some dermal bones collected by Dr. Maurice Rollot[2] from an old lake deposit in the southern part of the Bogotá Plateau, Colombia, South America. The bones are ascribed provisionally to *Mylodon robustus* Owen var. *tarijensis* Ameghino.

The presence of dermal bones in the mylodont group of ground-sloths has been known for many years. They were recorded as early as 1841 by Lund,[3] but apparently Burmeister[4] was the first to figure them and give a definite description of their appearance and a discussion as to their probable position in the skin of *Mylodon*. Conclusive evidence concerning the nature and position of such dermal armor in one mylodont genus, was furnished by the remarkably well preserved remains of *Glossotherium* (=*Neomylodon* and *Grypotherium*) discovered in a large cave at Consuelo Cove, Ultima Esperanza Inlet in the Magellan Territory of southern Chile. Skeletal material, the horny claws, fragments of the skin, and dung of the animal were collected by Eberhard and others in 1895, Nordenskjöld in 1896 and by Moreno in 1897. The nature and unusual preservation of this material caused much comment and speculation in the scientific world. Illustrations of the material were presented by Lönnberg,[5] Moreno and Woodward[6] and Hauthal, Roth and Lehmann-Nitsche[7] in 1899 and by Woodward[8] in 1900.

[1] Received May 1, 1933.

[2] Letter of September 18, 1932 from Dr. Maurice A. Rollot, Bogotá, Colombia to Prof. E. W. Berry of The Johns Hopkins University. . . . "et j'ai le plaisir de vous remettre aujourd'hui une collection . . . trouvées au contact d'un corps de *Mylodon*, au cours d'exploration y d'excavations, dans la partie sud du Haut Plateau de Bogotá. Le terrain appartient á une de ces anciennes lagunes e'tagées et supérandines, actuellement partiellement déséchées á une altitude de pres de 2.900 mts. . . . des os du *Mylodon*, qui put être identifié seulement á cause des dents, en tout semblable á ceux décrits par Marcelin Boule, dans son ouvrage sur les mammiferes fossiles du Tarija, S. A."

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[7] HAUTHAL, R., ROTH, S. and LEHMANN-NITSCHE, R. *El mammifero misterioso de la Patagonia,* Grypotherium domesticum. Revista Mus. de La Plata. **9**: 409–474, *pls. 1–5.* 1899.

[8] WOODWARD, A. S. *On some remains of* Grypotherium (Neomylodon) listai *and*

This brief paper does not warrant further references or more than the following short statement of some of the facts derived from the study of the *Glossotherium* remains. The skin described by Moreno and Woodward in 1899, is covered with hair varying in length from 10 to 65 millimeters and the bones are all confined to the inner portion of the dermis and never extend to the outer part in which the hair is implanted. The ossicles are irregularly arranged and closely spaced. The largest measure 10 by 15 millimeters, but the majority are smaller than this and large and small bones are indiscriminately mixed. They are irregular in form, the inner face is quite generally convex or pyramidal, the outer face slightly convex or more or less flattened, and there is no trace of definite patterns or sculpturing on them. This fragment of skin apparently came from the neck and shoulder region of the animal. A second fragment of skin, 100 by 93 centimeters, or almost twice the size of the preceding, was described by Woodward in 1900. It is supposed to have come from the trunk of the animal and there is a tendency, in what appears to be the middle part of the flank, for the ossicles to be arranged in rows parallel with the ribs. As the ventral border of the flank is approached, the bones dwindle in size or are lacking. The long axis of the elongate elements is nearly always coincident with the direction of the rows. A portion of skin bearing small ossicles was assigned more or less provisionally to the leg of the creature by Lönnberg in 1899.

In an article on the discovery of Quaternary mammals at Rancho La Brea, California, Merriam[9] recorded the occurrence of dermal bones in association with the remains of *Mylodon* and later[10] figured a layer of ossicles that were found more or less in their normal position, in a sheet of asphaltum overlying a mylodont scapula. Further remarks on the Rancho La Brea ossicles were contributed by Sinclair[11] who gave additional figures. The excellent report on the Cenozoic gravigrade edentates of North America by Stock[12] contains a review of the articles published on the dermal bones from the asphalt deposits. These bones are ascribed definitely to *Mylodon harlani* Owen.

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associated mammals from a cavern near Consuelo Cove, Last Hope Inlet, Patagonia. Proc. Zool. Soc. London, pp. 64–78, *pls. 5–9.* 1900.

[9] Merriam, J. C. *Recent discoveries of Quaternary mammals in southern California.* Science, n. s. **24**: 248–250. 1906.

[10] Merriam, J. C. *Death trap of the ages.* Sunset Magazine. **21**: 465–475. 1908.

[11] Sinclair, W. J. *Dermal bones of* Paramylodon *from the asphaltum deposits of Rancho La Brea, near Los Angeles, California.* Proc. Amer. Philos. Soc. **49**: 191–195. 1910.

[12] Stock, C. *Cenozoic gravigrade edentates of western North America, with special reference to the Pleistocene Megalonychinae and Mylodontidae of Rancho La Brea.* Carnegie Inst. Washington, Pub. No. **331**: 120–121, *pl. 21.* 1925.

The dermal ossicles from Colombia were found, as noted in the excerpt from Mr. Rollot's letter, in association with poorly preserved remains of a *Mylodon.* The teeth found with the skeletal remains appear to be similar to those of *Mylodon robustus* Owen var. *tarijensis* Ameghino, as figured by Boule[13] in an account of the fossil mammals from Tarija, Bolivia. On page 219, Boule mentions dermal bones from this animal, but does not describe or figure them. The Colom-

Fig. 1.—Dermal ossicles of *Mylodon* from Bogotá, Colombia. Natural size. Viewed from the upper surface.

bian material consists of some 250 individual bones, that range in size from 10 by 8 by 7.5 mm. to 28 by 16.5 by 15 mm. The largest and smallest specimens and others of intermediate size are illustrated in the accompanying figure. In preparing the bones for illustration, it was assumed that Woodward's observations on the orientation of the dermal ossicles in the skin of *Glossotherium* were correct and that supposedly the orientation, as suggested by Burmeister and others, was essentially similar in *Mylodon.* Therefore, the more highly pitted and less convex side, the so called, upper surface is represented in the

[13] Boule, M. *Mammiferes fossiles de Tarija.* With collaboration of A. Thevenin. Mission scientifique G. de Crequi-Monfort et E. Senechal de la Grange. H. le Soudier (Paris), 1920.

figure. All of the specimens from Colombia are stained by oxides of iron and manganese on their exterior surfaces and also stained on the interior, but the discoloration here is confined largely to the regions adjacent to the vascular canals. The outer, more dense layer of bone is generally light brown in color, whereas the central, more porous part, is pale yellow or white with an occasional growth of black dendritic wad. In a few of the broken specimens the central bone material has largely disappeared and such individuals present much the appearance of geodes or concretions. There are no surface markings on the exterior other than irregular ridges and grooves and the pits formed by the entrance of the vascular canals.

Most of the Colombian ossicles are larger than those of *Glossotherium* and apparently more irregular in outline and surface markings. Some of them are distinctly elongate and in this characteristic they are somewhat similar to the elongate, oriented elements that Woodward describes from the fragment of skin ascribed to the flank of *Glossotherium*. Several of the smaller specimens approach somewhat the degree of regularity exhibited by the quadrilateral forms from *Mylodon harlani* as figured by Sinclair (Fig. 1, *b, c, d*) and Stock (Plate 21). The majority compare rather closely in size and irregularity with the more unsymmetrical individuals figured by Stock. They appear to be more like the ossicles described from *Mylodon* and are referred provisionally to *Mylodon robustus* Owen var. *tarijensis* Ameghino.

PALEONTOLOGY.—*A new Pennsylvanian trilobite from Missouri.*[1] JAMES S. WILLIAMS, U. S. Geological Survey. (Communicated by GEORGE H. GIRTY.)

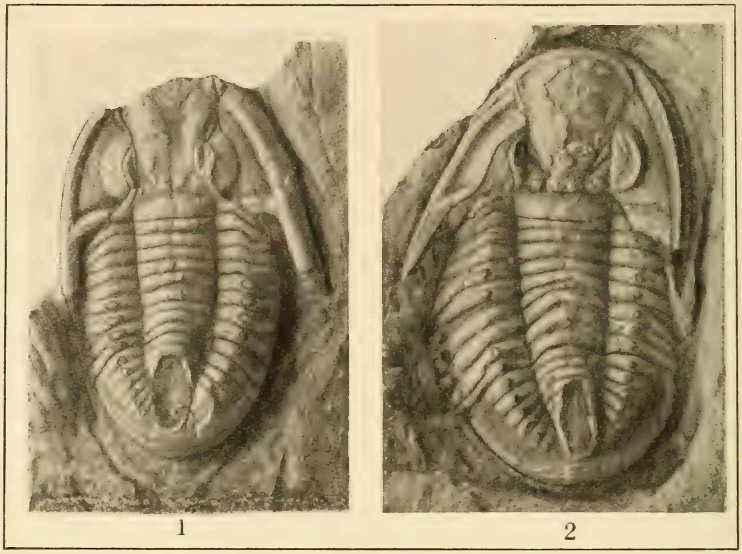
Complete dorsal shields of trilobites are rarely found in Pennsylvanian rocks, and their discovery is therefore always fortunate. If they represent new species, their description often prevents the creation of synonyms based on isolated parts. If they represent species previously known from incomplete specimens, the description may reveal the identity of two species or it may show that isolated pygidia and cephala placed in a single species are not truly conspecific.

The new species here described is based on two cotypes each of which has the cephalon, thorax, and pygidium in articulation. The typical specimens were collected by Mr. W. S. Olson and myself from the lower part of the Cherokee (lower Pennsylvanian) shale near Columbia, Missouri, in 1929, while studying the stratigraphy of the

[1] Published by permission of the Director of the U. S. Geological Survey. Received May 25, 1933.

Pennsylvanian rocks of the central Missouri fire-clay district. Although for many years trilobites have been known to occur in the Cherokee formation, this species is the first to be described from it from Missouri.

In describing this trilobite I have departed somewhat from the traditional practice and have given in advance of the detailed description and arranged under definite and mutually exclusive headings sufficient information for a working knowledge of the species. Although most paleontologists include this information in their de-



Figs. 1 and 2.—*Griffithides olsoni* Williams, n. sp. ×4. Fig. 1, cotype 5183; Fig. 2, cotype 5184.

scriptions, it is not always distinctly separated from the detailed description and is therefore sometimes difficult to find. If the specific characters were always summarized under definite headings, much unnecessary work by subsequent investigators would be avoided. The arrangement is by no means a new one. It has for a long time been in common use by some students of fossil vertebrates and some paleontologists have used it in describing genera and species of fossil invertebrates. It has not, however, been used to any extent by students of fossil invertebrates. A more extensive use of this arrangement would not only save time but would also be a step toward greater precision in fossil descriptions.

The photographs shown in the figures were made by N. W. Shupe and retouched by Miss Frances Wieser.

Griffithides olsoni Williams, n. sp.

Specific diagnosis: This species is characterized by the following combination of characters: small size, length less than twice the width, granulose surface, granules on glabella larger than those on rest of dorsal shield, most of granules on axial segments of thorax and pygidium irregularly arranged, small and inconspicuous basal lobes on glabella, no prominent mesial lobe between basal lobes, no transverse glabellar furrows except those that delimit basal lobes, nine segments in thorax, six complete pleural segments on pygidium.

Comparisons: In the number of segments on the pleural lobe of the pygidium, in its rather small size, and in several other characters, *G. olsoni* resembles *G. ornatus* Vodges, 1895, from the Pennsylvanian of Arkansas, *G. parvulus* Girty, 1911, from the Wewoka and Boggy formations of Oklahoma, and *G. scitulus* Meek and Worthen, 1865, a widespread Pennsylvanian species. Its closest resemblance is perhaps to *G. scitulus* and if the type of that species were available for study, my specimen might be found to be conspecific with it. I have, however, been unable to locate the type of *G. scitulus* and as a consequence must rely on the original and subsequent descriptions and on fragmentary and insecurely identified specimens in the United States Geological Survey collections from the type locality for data about it. Published figures do not show critical parts of the type in detail. Although *G. scitulus* has been described from several localities by different authors, it seems that Meek and Worthen were the only authors who examined the type.

G. olsoni differs from Meek and Worthen's original description of *G. scitulus* in the following ways: There are no indications of transverse glabellar furrows anterior to those that delimit the basal lobes on *G. olsoni; G. olsoni* has small basal lobes which, although the transverse furrows are not visible, appear to have raised portions that are more nearly suboval than subtriangular, and *G. scitulus* is said to have large subtriangular basal lobes; *G. olsoni* has no prominent mesial lobe between the basal lobes of the glabella. Another difference between *G. olsoni* and some forms described as *G. scitulus* is the absence of a single row of prominent nodes on each segment of the axis of the thorax and pygidium of *G. olsoni.* Although granules on some of the axial segments of *G. olsoni* appear to be so arranged, they are much smaller than the nodes attributed to *G. scitulus.* On some of the anterior segments of the thorax of *G. olsoni* granules are numerous but are not regularly arranged. They are only slightly smaller than the granules that appear to be regularly arranged and undoubtedly are morphologically the same. Their irregular arrangement suggests that the seeming regularity of some of the granules is due to the failure of others to be preserved. Meek and Worthen's descriptions of *G. scitulus* do not mention regularly arranged nodes and their possible presence on *G. scitulus* is based on descriptions by subsequent authors and on a row of nodes on the occipital segment of a fragmentary cephalon in the United States Geological Survey collection from the type locality of *G. scitulus.* Most of the differences cited are of degree rather than of kind but it seems better to place my specimens in a new species rather than to include them in one with whose description they do not agree, even though it seems likely that an examination of the type or of good specimens from the type locality may prove that description slightly misleading. If *G. scitulus* does have definite transverse glabellar furrows aside from those that delimit the basal lobes, as its description indicates, it does not conform fully to the description of *Griffithides.*

G. olsoni does not have the posterior part of its glabella divided into three knoblike nodes as does *G. parvulus;* it has no distinct indications of transverse glabellar furrows anterior to those that delimit the basal lobes as does this species; its facial sutures do not come nearly together in front; it does not, as before discussed, have single transverse rows of small but distinct nodes across the posterior part of the occipital segment and across each axial segment of the thorax and of the pygidium; and its length is less than twice its width. The length of *G. parvulus* is about two and one-half times its width.

From *G. ornatus, G. olsoni* differs because of its inconspicuous basal lobes, its smaller number of complete pleural segments on the pygidium, and its lack of distinct rows of rather large nodes on each axial segment of the thorax and pygidium. *G. ornatus* has basal lobes said to be prominent, seven complete pleural segments on the pygidium, and rather pronounced nodes arranged in a single row across each axial segment but grouped so as to form three double rows of nodes extending from the anterior of the thorax to the posterior of the axial lobe of the pygidium.

Walter[2] has suggested that the three species compared in the foregoing paragraphs with *G. olsoni* may belong to one species, *G. scitulus.* Of the types of these species, I have seen only that of *G. parvulus*, and can not test this suggestion adequately. It is undoubtedly true that changes in specific designations and perhaps in some of the kinds of characters used for specific distinctions will come when the trilobites of the Pennsylvanian are studied with the types and large collections assembled for careful scrutiny; and some species may then be found to be merely molts of other species. It is not desirable, however, to delay the description of newly collected material until such revisional studies are completed; and until new information based on typical material is available, it seems the most conservative course to recognize species as they are now generally recognized and use specific characters as they have been used.

Another species that is closely related to *G. olsoni* is *G. morrowensis* Mather 1915 from the Morrow group of Arkansas and Oklahoma. Mather's species is, however, a larger form. It has more pleural and probably more axial segments on its pygidium than does *G. olsoni*, and it also has a prominent median lobe between the two basal lobes of the glabella. Mather's figure suggests that it also has much narrower free cheeks.

Significance of name: This species is named for Mr. W. S. Olson, formerly of Columbia, Missouri, who collected one of the cotypes.

Type material: The cotypes are two in number. Both of them have the cephalon, thorax, and pygidium in articulation. Both also have part of the axis of the pygidium incomplete. The anterior part of the cephalon and part of the dorsal surface of the glabella has been removed by erosion from the smaller cotype. It is number 5183 of the type collections of Carboniferous invertebrate fossils of the United States Geological Survey; the larger cotype is number 5184 of the same collection.

Description: Carapace small, elliptical, slightly more than one and one-half times as long as wide; the cephalon, more than one-third as long as entire carapace, thorax shorter than cephalon, and pygidium about equal to or slightly shorter than thorax.

Cephalon semielliptical, evenly rounded in front on cotype 5184, incomplete in front of other cotype; surrounded by a longitudinally striated, narrow border or marginal rim which is distinctly above the free cheeks but is

[2] Walter, Otto T. Iowa Geol. Survey **31**: 334. 1926(?)

not as high as the anterior part of the glabella; the border appears to be turned up in front of the glabella on cotype 5184 but neither cotype is complete enough to enable one to determine certainly that it is; the border extends beyond the genal angles and forms spines which reach to the fifth or sixth thoracic segment and are about one-half as long as the cephalon. The spines gradually become narrower from the genal angles until within about a half-millimeter of their ends where they rapidly narrow to a sharp point; on cotype 5183 the raised border extends across the posterior margin of the cephalon from the genal angles to the facial suture but it is narrower there than on the sides; on cotype 5184, the border on the posterior of the cephalon is visible but it is lower and less distinct. *Facial sutures* distinct posterior to the eyes on both cotypes and on cotype 5183 almost to the marginal rim or border, but their course across the border can not be traced because the border is broken or partly broken at every place that the facial sutures intersect it. The facial sutures cut the posterior margin of the cephalon at a point about midway between the longitudinal dorsal furrows and the genal angles; they extend obliquely forward from this point almost to the glabella but before reaching the glabella curve away from it around the palpebral lobes; from the anterior of the palpebral lobes they go at angles of about 20° with the longitudinal axis of the carapace toward the anterior lateral margins of the cephalon. *Free cheeks* depressed, as wide as the glabella at the mid-length of the eyes, almost flat except at border and around eyes. Eyes large, extending from slightly in front of the occipital furrow nearly half the distance to anterior margin of cephalon; semilunate; elevated as high above general level of free cheek as marginal rim, but not as high as glabella; granules distinctly visible only on cotype 5183. *Cranidium* with a large glabella and narrow fixed cheeks. Palpebral lobes opposite posterior two-fifths of glabella; separated from it by a distinct furrow. Glabella pyriform, prominent, occupying about one-third the width of the posterior of the cephalon and probably extending to the anterior margin; it widens about one-third its posterior width at the anterior margin and is much more highly elevated anteriorly; its front is nearly perpendicular. The glabella is not so prominent on cotype 5183 but it has apparently been worn off by erosion of this specimen. Basal lobes inconspicuous and indistinct; evidently worn down on cotype 5183; probably almost entirely preserved on cotype 5184; as preserved, the basal lobes are more nearly suboval than subtriangular but the furrows separating the basal lobes from the rest of the glabella are not visible and they may be so slightly curving that they enclose subtriangular areas, parts of which are below the suboval areas, but this can not be ascertained and it appears most probable that the suboval raised areas constitute the basal lobes. Each lobe occupies about one-fourth the width of the posterior of the glabella. No other transverse glabellar furrows, except the occipital furrow, or indications of furrows are visible on cotype 5184. On the other cotype, a slight linear depression passes across the glabella in front of the basal lobes and if it were interpreted as a transverse glabellar furrow it would separate a median posterior lobe on the glabella from the anterior of the glabella. The absence of a transverse furrow on this part of cotype 5184, which is fairly well preserved, and the depth of the furrow and the presence of other furrows caused by erosion on the glabella of cotype 5183 strongly suggest that this is not a true glabellar furrow but is simply an erosional feature. *Occipital segment* about as wide as the two adjoining thoracic segments; separated from the rest of glabella by deep, wide furrow; surface of segment slopes upward from occipital furrow to posterior one-fourth of oc-

cipital segment where there is a narrow crest; a very short steep downward slope back of the crest continues to the posterior margin; a distinct node is visible in the center of the occipital segment on one cotype and is indicated on the other. *Surface* of glabella appears from fragments of the test preserved on cotype 5184 to have been rather coarsely pustulose; the remainder of the cephalon is less coarsely pustulose and pustules are not visible on many parts of it.

Thorax over one and one-half times as wide as long; slightly wider at anterior margin than at posterior margin; distinctly trilobate. *Axis of thorax* broad and moderately but not highly arched; more than twice the width of that portion of the pleural lobe above the abrupt down bending or fulcrum and equal or nearly equal to the entire width of pleural lobe. *Pleura* abruptly bent downward at about one-third their length from the longitudinal dorsal furrow; proximal portion of pleura forming a right or slightly obtuse angle with distal portion at fulcrum; on many of the pleural segments the angle formed at the fulcrum is extended into a distinct node. Each pleural segment is subdivided by a fine striation which extends below the fulcrum from near the longitudinal dorsal furrow and divides the segment into an anterior part which is about one-third and a posterior part which is about two-thirds as wide as the entire segment. Thorax of nine segments; distal ends of pleural segments not observed. *Surface of thorax* finely granulated but, aside from the nodes at the fulcra of the pleural segments, no granules large enough to be called nodes are present. On two or three posterior segments of the axis only a few granules are preserved and these have a linear arrangement which might give the impression that there is a single transverse row of granules across the segments of the axis of the thorax. Examination of anterior segments that are well preserved shows that they have many granules which are irregularly arranged and this observation suggests that the seeming arrangement of the granules in single transverse rows across the posterior axial segments may be only a result of the failure of many other granules to be preserved. The irregular arrangement of most of the granules and their small size prevents their being interpreted as nodes similar to those which are regularly arranged on many species of *Griffithides.*

Pygidium subsemielliptical, nearly twice as wide as long, surrounded by a smooth, uniform, slightly convex border which varies in convexity on different parts of the pygidium but does not vary much in width. *Axis* partly broken on both cotypes; from parts of axis preserved one would judge that it was prominent and highly arched but probably had a flattened area on top about equal to half its width. Axis extending from anterior of pygidium to marginal rim, about one-sixth length of pygidium from posterior of pygidium; gradually tapering, nearly twice as wide at anterior end as at posterior. Two anterior segments of axial lobe preserved on cotype 5183 and three anterior segments preserved on cotype 5184. A few fine irregularly arranged granules ornament the segments of the axis but no nodes are visible. Each lateral or *pleural lobe* bent nearly at right angles to the general plane of the carapace at about one-third its width from longitudinal dorsal furrow at front of pygidium; at the posterior part of pygidium the bend is about one-half the width of pleural lobe from the longitudinal dorsal furrow. A row of nodes, one at the fulcrum of each segment, ornaments each pleural lobe. Six complete and one incomplete pleural segments can be distinguished on the pygidium of cotype 5184 and on one side of the pygidium of cotype 5183; the other side of the latter cotype is not completely preserved. Pleural segments distinct; separated by distinct intersegmental furrows; not subdivided as

those of the pleura of the thorax by transverse striae; terminating in the smooth border that surrounds the pygidium. With the exception of the nodes at the fulcra there are no recognizable nodes on the pleural segments but a few granules on the pleural segments suggest that they were granulose.

Dimensions: Measurements of the two cotypes, 5183 and 5184, are respectively as follows:

Length of carapace 13 mm. and 14.4 mm.; greatest width of carapace, measured at posterior of genal spines, 8.3 mm. and 9 mm.; length of cephalon, including occipital segment, 5 mm. and 5.6 mm.; length of thorax 3.6 mm. and 4.3 mm.; length of pygidium 3.6 mm. and 4.2 mm.; greatest width of cephalon, 0.6 mm. and 0.6 mm.; approximate width of genal spines at genal angle, 0.65 mm. and 0.65 mm.; width of glabella at posterior of cephalon 2.6 mm. and 2.7 mm.; width of glabella at anterior margin, 3.2 mm. and 3.6 mm.; probable greatest diameter of basal lobes (measurements uncertain), 0.6 mm. and 0.6 mm.; width of occipital segment 0.7 mm. and 0.8 mm.; greatest width of thorax 6.9 mm. and 7.8 mm.; width of axis of thorax at anterior of thorax, 2.6 mm. and 3 mm.; width of portion of pleural segment above fulcrum, 0.9 mm. and 1.1 mm.; approximate width of portion of pleural segments below fulcrum 1.4 mm. and 2.1 mm.; width of pygidium, 5.4 mm. and 6.8 mm.; length of pygidium 3.8 mm. and 4.3 mm.; approximate width of border around pygidium, 0.65 mm. and 0.72 mm.; width of axis of pygidium at anterior of pygidium, 2 mm. and 2 mm.; approximate width of posterior end of axis of pygidium 1.1 mm. and 1.2 mm.; approximate length of axis of pygidium, 3.2 mm. and 3.6 mm.

Remarks: This species has relatively larger eyes than is characteristic of the genus. Although it has small irregularly arranged granules, it is also without the transverse rows of coarse pustules or nodes seen on many species of the genus. Its glabella is, however, typical of forms commonly referred to *Griffithides.*

Horizon and locality: Cherokee shale, probably about bed 15 of Broadhead's section[3] and horizon of bed 15 of Hinds and Greene's section,[4] nine feet above Tebo coal horizon, second limestone (about 30 feet) stratigraphically above Pennsylvanian-Mississippian contact: Hinkson Creek, east side of creek, about four feet above ordinary water-level, about one-eighth mile north of bridge on road from Columbia, Missouri, to Edwards brick plant; west of and in creek below brick plant. The locality is about 1 mile east of Columbia, Missouri, and about in the NW. $\frac{1}{4}$, sec. 8, T. 48 N., R. 12 W. The beds dip to the southwest at this exposure and basal Pennsylvanian fire-clay is exposed 30 to 40 feet north of and more or less continuous with the exposure.

[3] BROADHEAD, G. C. Missouri Geol. Survey **12** (pt. 3): 385. 1898.
[4] HINDS, HENRY and GREENE, F. C. Missouri Bur. Geology and Mines **13** (2nd ser.): 57. 1915.

PHYTOPATHOLOGY.—*The dark ages in Plant Pathology in America: 1830–1870.*[1] NEIL E. STEVENS, Bureau of Plant Industry. (Communicated by C. L. SHEAR.)

Many of the important activities in the history of plant pathology in the United States were initiated during the decade 1871 to 1880.

[1] Received February 16, 1933.

In 1871 there appeared in the Report of the Commissioner of Agriculture the first report on *The Fungoid Diseases of Plants* by Dr. Thomas Taylor, the recently appointed Microscopist of the Department. In 1873 Burrill first taught plant pathology incidentally with botany at the University of Illinois and in 1875 it was taught as a special subject by Farlow at Harvard. In 1875 also there was passed in Michigan the first law aimed at the eradication of peach trees affected by yellows and establishing the first quarantine against this disease. In 1879 Burrill transmitted the blight of pear by direct innoculation.

During this decade, there were established also the first State Experiment Stations. And soon after its close in 1882, Millardet in France began the experimental work with Bordeaux mixture, which was soon to have such an important bearing on American plant pathology. So important were the various lines of work initiated during this decade of 50 to 60 years ago that it is rather common to consider them the beginnings of plant pathology in this country as a recognized, organized study and the history of this branch of science since that time has been frequently reviewed. This, of course, makes all the more fascinating the assembling of information regarding the study of plant diseases and plant disease control prior to 1870. For the purposes of the present paper attention will be directed to the period 1830 to 1870.

THE ECONOMIC BACKGROUND

The period was not one favorable for intensive efforts at disease control. With the exception of the war years it was a period of tremendous crop surpluses and at times of great economic depression in agriculture. In the agricultural literature of the time one finds statements which sound strangely like those we have been reading during the last few years. For example, in a letter from A. Jackson to Dr. Coleman dated April 26, 1834, we find:

> "I ask, what is the real situation of the agriculturist? Where has the American farmer a market for his surplus produce? Except for cotton, he has neither a foreign nor a home market. Does not this clearly prove, when there is no market at home or abroad, that there is too much labor employed in agriculture? Common sense at once points out the remedy. Take from agriculture 600,000 men, women and children, and you will at once give a market for more breadstuffs than all Europe now furnishes."

This letter is quoted by Henry L. Ellsworth then Commissioner of Patents in his report dated January, 1843, (2) and he comments as follows:

"The present, too, seems to be the proper time for us to give to this question of the disposal of our immense surplus a thorough, calm, and deliberate investigation. On the decision of it the prosperity of this great country depends. It has been well said that, 'to encourage the progress of agricultural improvement is the only road to national wealth.' Our object should not be so much to stimulate to large production, as to open the ways and means by which the husbandman shall have a market, and shall know how his labor and skill may be most available."

Arguments, of course, were presented in favor of more intensive investigations and the improvement of methods. For example, in the Report of the Corresponding Secretary of the New York Agricultural Society for 1842, we find the following sentence:

"Amidst the cares and perplexities of a period of unexampled pecuniary disaster and agricultural depression, it is not perhaps singular that a want of leisure and a want of spirit should unit to interrupt the execution of such a task; but surely there is no time when the husbandman is more imperiously called upon to make diligent efforts to cheapen and render more available every process of tillage—to add to the value of his products and animals —in a word, to adopt correct, safe, and economical systems, than when the prices he receives for his products are lowest."

INTEREST IN AGRICULTURAL CHEMISTRY

Agricultural education seems to have largely centered on the study of chemistry and soils. A careful review of 14 American textbooks of agriculture published during this period (8) indicates a predominance of interest in problems of the composition of plants, composition of soils and in fertilizers. In only three or four of these texts do we find mention of plant diseases, and only one, *The American Text Book of Practical and Scientific Agriculture*, by Charles Fox, contains more than casual references to disease.

The faith of the farmers of the time in the ability of chemists to settle their problems is rather touching. We note, for instance, at a meeting of the Maryland Farmers' Club on December 13, 1845, that the Club wanted some information regarding a "troublesome disease of potatoes." It was, of course, the then newly discovered and exceedingly destructive late blight. They accordingly called upon Professor Baer, who was the "lecturing and practical agricultural chemist," and asked him to get a pound each of healthy and diseased potatoes and analyze them. His report in April, 1846, records his analyses and his conclusion that the disease was "a putrefactive fermentation produced by the condition of the atmosphere and improper cultivation."

DISEASE SURVEY WORK

The modest additions to our information regarding plant diseases made during this perod were not in their control but rather in records of their prevalence or what we would now call survey work. This was probably a direct reflection of the interest in geological surveys during the period or at least an outgrowth of the same attitude of mind which produced and developed the geological surveys. In Merrill's masterly sketch of American State Geological and Natural History Surveys (5), we note that no less than 29 States inaugurated such surveys during the period 1833 to 1865, following the example of North Carolina which had already organized a natural history survey in 1824. By comparison with the geological surveys the assembling of plant disease information was crude in the extreme. It may, however, be said in defense of these early workers that plant disease survey work is still undeveloped in comparison with the type of survey work carried on by geologists, and that those interested in plant disease information nearly a century ago fully realized the limitations of the conditions under which they were working.

We find that in 1842 the Commissioner of Patents, who was in charge of the agricultural work of the United States government, asked for funds which would enable him to make by observation in the field, a personal study of crops and agricultural implements. He also stated that during the previous year (1841) he had traveled in 10 states, where he had studied the crops, and was in this way better able to pass judgment on the statistics submitted to the Office.

Early in the period under review Massachusetts made an appropriation for an agricultural survey of the State and in the outline for this work published by Henry Colman in 1837, Commissioner for the Survey, plant diseases are specifically mentioned. It is perhaps natural that under conditions of economic stress, particularly those due to over-production, the tendency is toward surveys to see just where industry stands.

DISEASE CONTROL METHODS

The methods of disease control in use in this country from 1830 to 1870 were largely copied directly from European practices or carried over from previous experience. At least, I have thus far failed to find any distinctly new type of disease control developed during this period.

Barberry Eradication

Barberry eradication, which excited so much interest in Colonial Massachusetts and Connecticut between 1726 and 1764, had been

abandoned as a means of controlling wheat rust due apparently in part to a too great dependence on the mycology of the day. Thus we find in an 1843 prize essay of the New York State Agricultural Society by John J. Thomas on *The Diseases and Insects Injurious to the Wheat Crop* the following statement:

"The barberry.—This is not unfrequently supposed to be a cause of blight, and a slight similarity in external appearance between the barberry blight or rust and wheat rust, has contributed to the notion. But, on examination, these two kinds of blight are found to be caused by fungi totally different in appearance under a magnifier: they belong even to different genera, the one being the *Æcidium berberides,* and the other the *Puccinia graminis,* and the transmutation of one to the other would be equal to the absurdity of the conversion of wheat to chess."

It may be remembered, however, that barberry eradication as practiced in New England did not go unchallenged even during the eighteenth century, for in his notes on *Travels in the Confederation* (1783–1784), Johann David Schoepf (6) made the following observation:[2]

"In New England the common barberry is in evil repute. There is laid to its charge that its proximity is injurious to the growth of wheat and other field crops. Whether it is a positive or a negative injury, that is, whether it works damage actively, corrupting the atmosphere, or merely exhausts the better juices of the soil, nobody has been able or willing to determine. However, a strict law has been passed against the poor barberry, making the inhabitants responsible, with no further judicial process, for the carrying out of the death sentence imposed upon both varieties of this shrub, (elsewhere harmless) whenever it makes its appearance—if any man extends protection to the shrub his neighbor has the right to enter and destroy, and can bring action against the slothful or unbelieving condoner for damage and trouble incurred. But the New Englanders are known for other strange beliefs and practices as well, and it was among them that witch trials, at the beginning of the century, were so grimly prosecuted."

Seed Treatment

That the methods of seed treatment known in England were brought to this country and used by the more progressive farmers is evidenced by various references to it as a common practice. For example, in the report of the Commissioner of Patents for 1844 (2, p. 374) there is a detailed report of seed treatment for wheat smut:

"The substances used are, sulphate of copper, or blue vitriol, wine, common salt, wood ashes, lime water and sometimes arsenic. The smut which is sometimes found in wheat is called dust brand, or pepper brand. It is sometimes called *Uredo foetida.*

"A gentleman near Baltimore has for several years been in the habit of

[2] Quoted from the translation of Alfred J. Morrison (6)–1911.

washing his seed wheat in a strong solution of glauber salts, (sulphate of soda,) with the view of preventing smut with success. He says he makes the solution strong enough to bear an egg, fills a tub half full of it, and then pours in half a bushel of wheat at a time, stirs it round well with the hand, skims off all the floating grains and other foul matters, dips out the wheat with a colander, lets it drain, spreads it out on the barn floor till not quite dry, then rolls it in air slaked lime, and sows it.

"Dissolve a pound of blue stone in as much water as will cover five bushels of wheat, and let it remain about 18 hours before it is sown, and you will never have smut in your wheat."

"Sow your wheat the first of October, and when you harvest let what you intend to make seed of remain five or six days longer in the field before it is cut."

The use of these treatments was, of course, by no means universal, and we find in the report of the Commissioner of Patents in 1851 a report from Maryland and Virginia that most farmers sowed their wheat without any preparation. One farmer states, however, "I find that soaking my wheat in strong brine answers a valuable purpose and I never have smut with wheat so treated."

Soil and Cultural Treatments

The interest in the great epidemic of potato late blight was so intense that there were undoubtedly tried or at least suggested all the known disease control methods. The summary of the suggested methods is given in the Report of the Commissioner of Patents for 1844.

"The remedies suggested are: To keep such as are intended for seed deep buried in the ground all winter; thoroughly draining and subsoiling theland where planted; to put them in small quantities; to select seed for planting, not quite ripe, and such as have not the slightest appearance of being watery; liming the land; obtaining new seed, either from planting potato balls or from distant countries, where they grow in a healthy state; after digging, spread the potatoes in the sun till they become dry and unfit for food; then stow them away till required for planting—topdressing the plant with nitrate of soda and sulphate of soda and magnesia; selecting such tubers for seed as were grown near the top of the ground, and are quite green; to plant the seed whole. Salt, lime, and plaster, have been respectively recommended by their advocates, and, in some instances, with diverse success.

"An instance is related where, on planting, a tablespoonful of lime was placed in each hill; and, after they were up, was applied about a gill of a mixture—of lime 2 bushels, plaster 3, and ashes 8. In this case there was not one rotten potato in the fall, while in the fields of his neighbors they were much diseased."

AN EARLY ANALYSIS OF PEACH AFFECTED WITH YELLOWS

The great interest in and devotion to chemistry during the period is evident in relation to plant diseases. Thus we find in 1849 that

Emmons (3) published in a paper on *Analysis of Fruit Trees*, an analysis of leaves of a healthy peach tree and one affected with yellows. This analysis was quoted and commented on in at least one textbook of the period, and represents another early attempt in this country to gain information about a disease by analyzing the affected host parts.

THE SPREAD OF POTATO LATE BLIGHT 1843–1845

The most notable disease outbreak of the period, indeed one of the most notable in our national history, was that of late blight of potatoes (caused by *Phytophthora infestans* [Mont.] DeBy). Reference to attempts at control has already been made, and in justice to a little known student of American botany it should be said that as early as 1845 J. E. Teschemacher, Curator in Botany of the Boston Natural History Society, had studied the disease and become convinced that it was caused by a fungus. He wrote his opinion to Commissioner Colman, and the letter was published in the Gardeners' Chronicle (7) and is cited by Berkeley (1).

Of chief interest to us, however, is the record of the spread of the disease in the United States found in the records of the Commissioner of Patents. In view of the importance of the disease and the crop, and particularly of the world wide interest in the disease as a major cause of the Irish famine of 1845 and 1846, it is surprising that no maps of its spread have been prepared and published. I fail to find any, however, in available literature. The reports are remarkably full and accurate for the critical years. Definite parts of States are often indicated and in at least one year latitudes are specifically mentioned. There can be no question that the disease dealt with is late blight. For example, the report for New York for 1843 (2), says: "Potatoes are subject to dry rot, attacking some in the hill, and some in the heap, and fatal to the whole wherever it makes its appearance, causing them to rot and to emit a very offensive stench."

No records of the disease being observed in 1842 could be found either in the transactions of any of the Horticultural Societies or in the Report of the Commissioner of Patents. On the contrary, in all the New England States as well as New York, New Jersey, Pennsylvania, Maryland, and Virginia west of the mountains (that is West Virginia) there are reports of an average or better than average yield of potatoes and where quality is indicated it was above average. The rot is everywhere referred to in 1843 and 1844 as a "New Disease."

The only reference in available literature to the disease as occurring

in this country in 1842 is based on a letter written in 1887, 45 years after the event. The impression that late blight was observed in the United States in 1842 is apparently drawn from Farlow's paper *The Potato Rot* (4). But Farlow had but recently returned from study in Europe and was obviously referring to world conditions when in 1875 he wrote, "The disease occurred in this violent form in 1842, and again in 1845."

The progress of the disease is best shown by the maps. There are

Fig. 1. The known distribution of potato late blight in 1843.

definite records of the disease in 1843 in the five States nearest Philadelphia and New York City, (Fig. 1), with Pennsylvania and Delaware estimating losses of 50 per cent, and New York reporting some counties with 50 per cent and others from 12 to 15 per cent. The New Jersey report for the next year indicates that the loss due to this disease in 1843 exceeded 15 per cent. The presence of the disease in Connecticut is indicated but no estimate of loss is given. The Maine crop appears to have had "its usual good quality."

In 1844 there was evidently great interest in the disease. The records are full and definite. They are summarized as follows in the Report of the Commissioner of Patents:

"So far as we have been able to trace its boundary, it has not in any instances in this country extended beyond 45° northern latitude nor farther south than the 37°, if indeed it has gone so far. We have not observed any notice of it higher up than Piscataquis County, Maine. It does not seem to have gone lower than a line drawn diagonally through Trumbul County in Ohio, and so passing through part of Pennsylvania and on down to the District of Columbia. There seems to be none of it in Canada." (Fig. 2.)

The disease had thus apparently not reached the important potato producing area of Maine. Even in the southeastern section of that

Fig. 2. The known distribution of potato late blight in 1844.

State it was reported that there was "A good crop, very few rotted, and the quality good."

In the other New England States, however, as well as in New York, Pennsylvania, New Jersey, and Delaware, severe losses were noted, although they were apparently less in New Jersey and Pennsylvania than during the previous year (1843). In Maryland and West Virginia the crops were below normal but this is definitely stated to be due chiefly to drought. In Ohio there was also a falling off in the crop due to drought, and in the northeastern part of the State most of the crop was reported to have rotted after harvest. (See Table I.) The report that the potato crops in Maryland, West Virginia, and southern

TABLE 1

Estimates of the Potato Crop of Various States in 1844, in Comparison with Previous Years, as Affected by the Factors Indicated:

Percentage losses due to late blight		Percentage shortage due to drought		Percentage increase in yield over previous years	
New Hampshire	25	Maryland	25 to 30	Maine	+15
Vermont	25	West Virginia	20	Michigan	+20
Massachusetts	25 to 30	Ohio	25	Indiana	+25
Rhode Island	10			Wisconsin	a considerable increase
Connecticut	25 to 30			Iowa	
New York	50				
New Jersey	15				
Pennsylvania	20 to 25				
Delaware	25 to 30				

Fig. 3. The known distribution of potato late blight in 1845.

Ohio were short due to the drought is substantiated by such weather records as are available. For instance, in Washington, D. C., and Baltimore, Maryland, the total rainfall for the year 1844 was 32.46 inches as compared with a normal of 41 inches, and the rainfall for June, July, and August, was 1.70, 3.90, and 0.31, respectively, while the normals are about 4.10, 4.49, and 4.22. A somewhat similar although smaller difference appears in the records for Marietta, Ohio.

Reports indicate that in 1844 the group of States around Lake Michigan produced a potato crop well above the average. Michigan reports 20 per cent increase over the previous year, Indiana, 25 per cent increase, and Wisconsin better than average.

In 1845, the Patent Office Report states that the disease was noted farther East, West, North, and South than the previous year, and specifically mentions its appearance in Illinois, Indiana, and Michigan. It also spread to Canada and Nova Scotia, and was "very severe" in Maine. Its distribution in 1845 is indicated in Fig. 3.

There is no report on agriculture by the Commissioner of Patents for 1846, but apparently losses from late blight continued severe through 1847 being mentioned from Maine, Massachusetts, New York, Maryland, and Ohio.

By 1848, the disease had apparently become recognized as one of the important factors in potato growing, and losses were being compared with previous years, although the hope was still entertained that the disease might soon spend its strength. There are, of course, numerous reports in 1850 and 1851 but these become so scattered and generalized as to be of little value.

He would indeed be a rash historian who would insist that the great epidemic of 1843–45 was the first occurrence of late blight of potatoes in North America, since the beginning of potato cultivation or even since the arrival of Europeans. The first appearance of the disease near the great ports, and its rapid spread in three growing seasons, during which it reached something near the limits of what finally proved to be its area of greatest importance both suggest a recent introduction. As the disease was well established in Ireland, England, and on the continent of Europe in 1842 its prompt introduction on the Atlantic Seaboard of North America can be easily understood. That one can now prepare maps of the annual spread of the disease, exceeded in accuracy in our own day only by the maps of the spread of the chestnut bark disease, is no small tribute to the plant disease reports of ninety years ago.

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SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

Science advisory board.—One of the most important steps that has yet been taken by the new Administration is the appointment, by executive order dated July 21, of a Science Advisory Board to cooperate with the Federal Government in the handling of all problems in which science is involved.

The President's executive order establishing the new board is as follows:

"The National Research Council was created at the request of President WILSON in 1916 and perpetuated by Executive Order No. 2859, signed by President WILSON on May 11, 1918. In order to carry out to the fullest extent the intent of the above Executive Order there is hereby created a Science Advisory Board with authority, acting through the machinery and under the jurisdiction of the National Academy of Sciences and the National Research Council, to appoint committees to deal with specific problems in the various departments.

"The Science Advisory Board of the National Research Council will consist of the following members who are hereby appointed for a period of two years: KARL T. COMPTON, Chairman, President, Massachusetts Institute of Technology, Cambridge, Massachusetts; W. W. CAMPBELL, President, National Academy of Sciences, Washington, D. C.; ISAIAH BOWMAN, Chairman, National Research Council, and Director, American Geographical Society, New York City; GANO DUNN, President, J. G. WHITE Engineering Corporation, New York City; FRANK B. JEWETT, Vice-President, American Telephone and Telegraph Company, and President, Bell Telephone Laboratories, Incorporated, New York City; CHARLES F. KETTERING, Vice-President, General Motors Corporation, and President, General Motors Research Corporation, Detroit, Michigan; C. K. LEITH, Professor of Geology, University of Wisconsin, Madison; JOHN C. MERRIAM, President, Carnegie Institution of Washington, Washington, D. C.; R. A. MILLIKAN, Director, Norman Bridge Laboratory of Physics, and Chairman of the Executive Council, California Institute of Technology, Pasadena, California."

Great white spot on Saturn.—A white spot, so large that it could engulf an object over twice the diameter of the earth, has appeared suddenly on the equator of Saturn, the ringed planet and second largest of the solar system.

It was discovered by JOHN E. WILLIS, U. S. Naval Observatory astronomer at 12:18 A.M. Saturday, August 5, while he was observing Saturn through the six-inch transit instrument. Although he observed the planet for only about a minute before it left the field of view, Mr. WILLIS recognized the spot and called upon other astronomers at the observatory to check his discovery. Principal Astronomer H. E. BURTON turned the 26-inch

and the 12-inch telescopes upon the planet and confirmed the discovery. Capt. J. F. Hellweg, superintendent of the Naval Observatory, reported the discovery to Harvard College Observatory, when it was bulletined to observatories throughout the world.

The spot was also noticed by a London music hall comedian and amateur astronomer, Will Hay, nearly 27 hours before it was found independently at the Naval Observatory. Mr. Hay was looking at the planet Thursday night, August 3, through a six-inch refracting telescope at Norbury when he saw the spot and notified Dr. W. H. Steavenson who confirmed the discovery. The British Astronomical Association issued a bulletin on the discovery which was circulated among British astronomers.

On Saturday morning it was estimated that the spot was about a tenth the diameter of the planet, but on Saturday night Principal Astronomer Burton with the 26-inch telescope found that the spot was much larger. While difficult to measure because not well defined, the spot seemed to be about 20,000 miles long and 12,000 miles wide, being formed by a sort of extension in the brighter equatorial belt of the planet. It is expected that the spot will continue to be observable for several weeks.

Only twice before do astronomical records show that such spots have been observed on Saturn. The first was seen through the same 26-inch Naval Observatory lens in 1876 by the Late Prof. Asaph Hall, Sr., just three years after the telescope was built. By using the spot as a mark of reference Prof. Hall was able to make the determination of the period of rotation of Saturn that is now quoted in astronomical tables, 10 hours, 14 minutes, 24 seconds. The 1876 Hall spot was not so large as the Willis spot now visible. Mr. Willis used the Hall determination of Saturn's period of rotation in predicting when the spot would return to visibility, and Saturday night's observations showed that the Willis spot is revolving around on the planet in about the expected time. The second spot on Saturn was discovered by the late Prof. E. E. Barnard of Yerkes Observatory in 1903. Unlike the Hall and Willis spots, the Barnard spot was considerably north of the planet's equator.

International Geological Congress.—The International Geological Congress held its sixteenth session in Washington, from July 22 to 29. The last preceding session had been held in South Africa in 1929. The Washington meeting was distinguished by the considerable number of foreign delegates and guests, in addition to a full attendance by American geologists.

Papers at the session grouped themselves around the following general topics: measurement of geologic time, batholiths and related intrusives, zonal relations of metalliferous deposits, major divisions of the paleozoic era, geomorphogenic processes in arid regions, fossil man and contemporary faunas, orogenesis, geology of petroleum, geology of copper deposits, miscellaneous ore deposits.

One of the outstanding papers was that of Sir Arthur Smith Woodward, who reviewed and brought down to date all the data concerning ancient man in the Old World, with special reference to *Sinanthropus* and his relations to *Eoanthropus* and modern man. At the same session the present status of the still-vext question of man's antiquity on the American continent was discussed by Dr. J. C. Merriam, Dr. Chester Stock and Barnum Brown.

The meeting in Washington was preceded by several field excursions into various regions of geological interest in the eastern, southeastern and central states, together with a transcontinental excursion starting from San

Francisco, for the benefit of western and trans-Pacific geologists. At the close of the sessions two additional excursions, both transcontinental, took the field.

Agreement on mineralogical nomenclature.—A joint session of the British and American committees on mineralogical nomenclature was held during the Sixteenth International Geological Congress, in Washington, D. C., July 25, 1933, and was specially notable in the almost complete accord reached in the subjects under discussion. The aim of the joint meeting was to strive for uniformity in the names used for mineral species, in spelling and pronunciation, and in the symbols used in mineralogical and crystallographical descriptions. On a very few items only was it deemed advisable to refer the questions to a subcommittee for further debate.

The British Committee, representing the Mineralogical Society of Great Britain and Ireland, consisted of Sir JOHN FLETT, Director of the Geological Survey of Great Britain, Chairman; Dr. W. CAMPBELL SMITH of the Mineral Department, British Museum; and Prof. CHARLES G. CULLIS, Professor of Economic Mineralogy, Imperial College of Science and Technology, London.

The members of the American Committee, representing the Mineralogical Society of America, who were present consisted of Dr. WALDEMAR T. SCHALLER, U. S. Geological Survey, Washington, D. C., Chairman; Prof. ESPER S. LARSEN, Harvard University; Dr. CLARENCE S. ROSS, U. S. Geological Survey (who proxied for Dr. WILLIAM T. FOSHAG, U. S. National Museum); Dr. J. FRANK SCHAIRER, Carnegie Geophysical Laboratory; Prof. T. L. WALKER, University of Toronto; and Prof. E. T. WHERRY, University of Pennsylvania. Prof. A. N. WINCHELL, University of Wisconsin, was unable to attend.

Abstracting service.—On June 22, 1933, a conference was held at the University of Chicago with Professor J. R. SCHRAMM, editor of *Biological Abstracts,* and with associate editors, Drs. W. C. ALLEE, GEORGE D. FULLER, CHANCEY JUDAY, and several others for the purpose of perfecting plans to provide fishery research workers in America with an adequate abstracting of scientific literature bearing upon their field of work. The Bureau of Fisheries was represented by ELMER HIGGINS, Chief of the Division of Scientific Inquiry, who has been active in promoting the project.

It was tentatively decided to establish a separate heading for abstracts of papers dealing with Fisheries Biology and Aquiculture, giving them independent rank comparable in importance to such branches of science as animal husbandry and economic entomology.

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BOTANY.—*New species and new names of grasses from Texas.*[1] A. S. Hitchcock, Bureau of Plant Industry.

In the course of the preparation of a manual of grasses of the United States it has been found necessary to describe several new species and to transfer a few names. The following descriptions and transfers concern grasses found in Texas.

Bromus anomalus var. **lanatipes** (Shear) Hitchc.

Bromus porteri lanatipes Shear, U. S. Dept. Agr. Div. Agrost. Bull. **23**: 37. 1900.

Eragrostis arida Hitchc., sp. nov.

Annua; culmi tenerae, basi ramosi, 20–40 cm. alti; laminae planae, longe acuminatae, 4–8 cm. longae, 1–2 mm. latae; panicula erecta, patula, 8–15 cm. longa, ramis in axillis glabris vel paullum pilosis, solitariis vel inferioribus binis; spiculae oblongae vel lineares, stramineae, 8–15-flores, 5–10 mm. longae, 1.5–2 mm. latae, pedicellis patulis flexuosis lateralibus 2–3 mm. longis; glumae acutae, prima angusta 1 mm. longa, secunda paullum longior et latior; lemmata 1.6–1.8 mm. longa, acutiuscula; palea persistens.

Annual; culms branching at base, slender, erect or somewhat decumbent at base, 20 to 40 cm. tall; sheaths glabrous, pilose at the summit, the hairs in a dense line part way along the collar; ligule a dense line of hairs about 0.5 mm. long; blades flat or sometimes folded or loosely involute, glabrous, tapering to a fine point, mostly 4 to 8 cm. long, 1 to 2 mm. wide; panicle one-third to half the entire height of the plant, erect, open, the branches, branchlets, and pedicels spreading, the axils glabrous or the lower sparsely pilose, the branches solitary, rather distant or the lower in pairs; spikelets oblong to linear, stramineous or drab, mostly 8 to 15-flowered, 5 to 10 mm. long, 1.5 to 2 mm. wide, somewhat compressed, the pedicels flexuous, the lateral 2 to 3 mm. long; glumes acute, the first narrow, scarcely 1 mm. long, the second a little longer and wider; lemmas 1.6 to 1.8 mm. long, acutish; palea scarcely as long as the lemma, persistent; grain 1 mm. long.

Type in the U. S. National Herbarium, no. 905937, collected on prairie at Del Rio, Texas, September 14, 1915, by A. S. Hitchcock (no. 13650).

This species has been confused with *Eragrostis suaveolens* Becker, *E.*

[1] Received August 10, 1933.

mexicana (Lag.) Link, *E. pilosa* (L.) Beauv., and *E. limbata* Fourn. It differs from *E. suaveolens* in the smaller size, the lack of glands on the sheaths, and the slightly smaller spikelets; from *E. mexicana* in the smaller and more slender stramineous spikelets; from *E. pilosa* in the larger spikelets; from *E. limbata*, which is confined to Mexico, in its larger panicles, longer stramineous spikelets, and more acute lemmas.

Dry soil, Texas to Arizona and central Mexico.

TEXAS: Lubbock, *Whitehouse* 7509; Amarillo, *Hitchcock* 16205; Edinburg, *Swallen* 1081; Del Rio, *Hitchcock* 13650; Lyford, *Hitchcock* in 1904; New Braunfels, *Hitchcock* 5196.

ARIZONA: South of Bisbee, *Mearns* 1028, 1071; Baboquivari Mountains, *Gilman* A 20.

NEW MEXICO: Carlsbad, *Hitchcock* 13487.

SONORA: South of Nogales, *Griffiths* 6793. Hermosillo, *Hitchcock* 3593.

CHIHUAHUA: Candelaria, *Stearns* 261.

DURANGO: Tlahualilo, *Pittier* 476.

NAYARIT: Acaponeta, *Rose* 14321.

Eragrostis intermedia Hitchc., sp. nov.

Perennis; culmi erecti, caespitosi, 40–80 cm. alti; vaginae glabrae, apice valde pilosae; laminae planae vel plus minusve involutae, plerumque glabrae; 10–20 (–30) cm. longae, 1–3 mm. latae; panicula erecta, patula vel diffusa, 15–35 cm. longa, in axillis pilosa, ramis patulis, tenuibus, solitariis, inferioribus duobus vel tribus; spiculae 3–9-flores, 3–10 mm. longae, pedicellis flexuosis, 5–15 mm. longis; glumae acutae, prima 1–1.2 mm. longa, secunda 1.2–1.4 mm. longa; lemmata turgida, obscure nervata, 1.8–2 mm. longa; palea persistens.

Perennial; culms erect, tufted, mostly 40–80 cm. tall; sometimes taller; sheaths glabrous or the lowermost sparsely pilose, conspicuously pilose at the throat, the hairs extending in a line across the collar; ligule a dense line of hairs less than 0.5 mm. long; blades flat or more or less involute, especially those of the innovations, pilose on the upper surface near the base, otherwise glabrous or sometimes with a few scattering hairs, scabrous toward the fine involute point, 10 to 25 cm. long, sometimes as much as 30 cm., 1 to 4 mm. wide; panicle erect, open, often diffuse, 15 to 35 cm. long, at maturity usually about two-thirds as wide, pilose in the axils, sometimes sparsely so, rarely glabrous, the branches slender but rather stiff, solitary and somewhat distant or the lower in pairs or verticils, all spreading, often widely or horizontally, the branchlets and pedicels ascending or spreading; spikelets 3 to 8, rarely 9-flowered, 3 to 9, rarely 10 mm. long, 1 to 1.5 mm. wide, grayish or brownish green, the pedicels somewhat flexuous, minutely scabrous, 1 to 3 times as long as the spikelet; glumes acute, the first 1 to 1.2 mm. long, the second 1.2 to 1.4 mm. long; lemmas turgid, obscurely nerved, 1.8 to 2 mm. long, usually bronze-tipped, not hyaline-margined; palea about as long as the lemma, persistent, minutely scabrous on the keels; caryopsis oblong, about 0.7 mm. long.

Type in the U. S. National Herbarium, no. 1535749 collected in moist place in gravel pit near San Antonio, Texas, July 3, 1910, by A. S. Hitchcock (no. 5491).

The following specimens, previously referred to *Eragrostis lugens* Nees, are representative of the species:

Missouri: Sheffield, *Bush* 9222; Redings Mill, *Bush* 5064.

Georgia: Athens, *Harper* 32, *Weatherwax* 11; Camelle, *Tracy* 3729.

Louisiana: Lake Charles, *Chase* 6113; Avery Island, *Hitchcock* 19863; Natchitoches, *Ball* 152.

Arkansas: Fayetteville, *Hitchcock* 16076.

Oklahoma: Wichita Mountains, *Swallen* 1004, 1025, *Rose* 112; Sapulpa, *Bush* 810; Stillwater, *Hitchcock* 16156.

Texas: *Bailey* 742; *Bogush* 1318; *Bush* 304; *Drummond* 328; *Fisher* 2059; *Griffiths* 6290; *Hall* 788; *Havard* 33; *Heller* 1745; *Hitchcock* 5167, 5219, 5268, 5287, 5294, 5371, 5491, 13611, 13645, 13646; *Moore & Steyermark* 3176; *Mulford* 99; *Nealley* 499; *E. J. Palmer* 31857, 32138a; *Plank* 93, 95; *Reverchon* 1125, 1125A; *Silveus* 81, 141, 368; *Standley* 40553; *Swallen* 976, 1103, 1540, 1799, 1863; *Tharp* 5024, 5163; *Tracy* 7918, 7926, 7928, 8235, 8876.

New Mexico: *Blumer* 184; *Greene* 402; *Hitchcock* 3800, 13535; *Mearns* 680, 2097; *Metcalfe* 1329; *Rose & Fitch* 1764, 17,670; *Wright* 2048, 2050.

Arizona: *Griffiths* 1843, 1853, 3433, 4857, 5948, 6067, 6969, 7141; *Griffiths & Thornber* 58; *Hitchcock* 3688, 3709, 3725, 3726, 13271; *Jones* 4226; *Lemmon* 338, 2906; *Mearns* 1166, 1910; *Purpus* 8280; *Toumey* 735, 736; *Wilcox* 159.

This species extends into northern Mexico.

Eragrostis swalleni Hitchc., sp. nov.

Perennis; culmi dense caespitosi erecti, 20–50 cm. alti; infra nodo glanduloso-cincti; vaginae glabrae, apice paullum pilosae; laminae involutae, glabrae, 10–30 cm. longae; panicula erecta, patula, 10–20 cm. longa, in axillis glabra, ramis ascendentibus vel patulis, glabris, flexuosis; spiculae oblongo-lineares, stramineae vel cano-virides, 7–10 mm. longae, 8–14-flores, pedicellis supra medium glanduloso-cinctis; lemmata imbricata, adpressa, 2 mm. longa; palea persistens.

Perennial; culms in dense tufts, erect, 20 to 50 cm. tall, an obscure glandular band below the nodes; sheaths glabrous, sparingly pilose at the throat; ligule a dense line of hairs about 0.5 mm. long; blades firm, arching-recurved, mostly involute, glabrous, the lower sometimes with a few long hairs, 1 to 1.5 mm. thick when rolled (1 to 2 mm. wide when flat), 10 to 30 cm. long, the uppermost not greatly reduced; panicle erect, open, 10 to 20 cm. long, mostly short-exserted, the axis and branches glabrous, the branches ascending to spreading, stiffly flexuous, rather few-flowered, glabrous in the axils; spikelets oblong to linear, stramineous or grayish green, 7 to 10 mm. (rarely to 12 mm.) long, about 2 mm. wide, mostly 8 to 14-flowered, the stiff slender pedicels bearing a glandular band or spot above the middle; glumes acutish, rather broad, the first 1.2 mm. long, the second 1.5 to 1.8 mm. long; lemmas rather closely imbricate, appressed, acutish about 2 mm. long; palea about as long as the lemma, persistent, minutely scabrous on the keels; grain nearly smooth, somewhat narrowed toward the summit, 1 mm. long.

Type in the U. S. National Herbarium, no. 1,535,332, collected on sandy prairie at Riviera, Texas, June 8, 1931, by Jason R. Swallen (no. 1847).

Four other specimens were collected on sandy prairie at Sarita, *Hitchcock* in 1904 (August 7), *Hitchcock* 5449 and 5489 (June 27, 1910), and *Swallen* 1517 (April 17, 1931).

The species is allied to *Eragrostis erosa* Scribn., but is distinguished by the dense bunches, lower culm, smaller panicles, and especially the glandular band on the pedicels.

Vaseyochloa Hitchc., gen. nov.

Spiculae subteretes, multiflorae; lemmata imbricata 7–9-nervia, apice integra, dorso inferiore marginibusque pubescentia; panicula angusta; planta perennis, foliis elongatis.

Spikelets subterete or slightly compressed, several-flowered, the rachilla disarticulating above the glumes and between the florets, the joints very short; glumes rather firm, unequal, much shorter than the lemmas, the first 3 to 5-nerved, the second 7 to 9-nerved; lemmas rounded on the back, firm, closely imbricate, 7 to 9-nerved, broad, narrowed to an obtuse entire apex, and with a stipelike hairy callus, pubescent on the lower part of the back and margins; palea shorter than the lemma, splitting at maturity, the arcuate keels strongly wing-margined; caryopsis concavo-convex, oval, black, the base of the styles persistent as a 2-toothed crown. Slender perennial with elongate blades and narrow panicles.

Type species, *Melica multinervosa* Vasey.

Vaseyochloa multinervosa (Vasey) Hitchc.

Melica multinervosa Vasey, Bot. Gaz. **16**: 235. 1891.
Distichlis multinervosa (Vasey) Piper, Proc. Biol. Soc. Washington **18**: 147. 1905.
Triodia multinervosa (Vasey) Hitchc. Proc. Biol. Soc. Washington **41**: 159. 1928.

Triodia buckleyana (L. H. Dewey) Vasey

Sieglingia buckleyana L. H. Dewey, Contr. U. S. Nat. Herb. **2**: 540. 1894.
Triodia buckleyana Vasey; Dewey, Contr. U. S. Nat. Herb. **2**: 540. 1894, as synonym of *Sieglingia buckleyana* L. H. Dewey.

The nomenclature here illustrates several cases in which names first recorded as synonyms are later accepted as valid. The original specific name *buckleyana* (under *Sieglingia*) must be used under *Triodia*, but since citation as a synonym is not valid publication I publish the name here in order to validate it. I have chosen to give Vasey as the author of the combination, but the date of effective publication is that of the present paper. Had I chosen to omit Vasey as the author, in making the transfer, the combination as credited to me would have been legitimate.

Elymus virginicus var. **australis** (Scribn. & Ball) Hitchc.

Elymus australis Scribn. & Ball, U. S. Dept. Agr. Div. Agrost. Bull. **24**: 46. *f. 20*. 1901.

Hordeum pusillum var. **pubens** Hitchc., var. nov.

Spiculae pubescentes.

Glumes and lemmas pubescent; spikes usually somewhat broader; dilated glumes wider. In some cases the pubescence is rather scant.

Type in the U. S. National Herbarium, no. 270730, collected at La Verkin, Utah, by Marcus E. Jones (5196W.). The following specimens belong to this variety:

TEXAS: Arlington, *Allen* 20; San Antonio, *Havard* 5.
UTAH: Springdale, *Jones* 5253.
ARIZONA: Santa Rosa to Casa Grande, *Griffiths* 4043.

Sphenopholis longiflora (Vasey) Hitchc.

Eatonia pennsylvanica var. *longiflora* Vasey; L. H. Dewey, Contr. U. S. Nat. Herb. **2**: 544. 1894.

Muhlenbergia utilis (Torr.) Hitchc.

Vilfa utilis Torr. U. S. Rep. Expl. Miss. Pacif. 5^2: 365. 1857.

Allied to *M. repens* (Presl) Hitchc., to which it has been referred as a synonym. It is a more delicate species with finer leaves and smaller spikelets, and is confined to moist places.

Muhlenbergia fournieriana Hitchc.

Epicampes berlandieri Fourn. Mex. Pl. **2**: 89. 1886. Not *Muhlenbergia berlandieri* Trin. 1841.

Muhlenbergia rigens (Benth.) Hitchc.

Epicampes rigens Benth. Journ. Linn. Soc. Bot. **19**: 88. 1881.

Sporobolus microspermus (Lag.) Hitchc.

Milium microspermum Lag. Gen. & Sp. Nov. 2. 1816.
Sporobolus confusus Vasey, Bull. Torrey Club **15**: 293. 1888.

Piptochaetium fimbriatum (H.B.K.) Hitchc.

Stipa fimbriata H.B.K. Nov. Gen. & Sp. **1**: 126. 1815.
Oryzopsis fimbriata Hemsl. Biol. Centr. Amer. Bot. **3**: 538. 1885.

Aristida ternipes var. **minor** (Vasey) Hitchc.

Aristida schiediana var. *minor* Vasey, Bull. Torrey Club **13**: 28. 1886.
Aristida divergens Vasey, Contr. U. S. Nat. Herb. **3**: 48. 1892.

Bouteloua rigidiseta (Steud.) Hitchc.

Aegopogon rigidisetus Steud. Syn. Pl. Glum. **1**: 146. 1854.
Bouteloua texana S. Wats. Proc. Amer. Acad. **18**: 196. 1883.

The type of *Aegopogon rigidisetus* was collected in Texas by Drummond. Steudel gives no number, but it may be no. 340 or no. 374. Both numbers

are in the Edinburgh Herbarium and no. 340 is in the Trinius Herbarium. The specimens cited by Watson under *B. texana* are *Berlandier* 1535, *Drummond* 340, 374, *Lindheimer* 732, *Wright* 752. Griffiths, in his revision of *Bouteloua*, designates the first cited specimen (*Berlandier* 1535) as the type. This is in the Gray Herbarium. Watson states that his *B. texana* "appears to be the *Aegopogon rigidisetus* of Steudel."

Bouteloua gracilis var. **stricta** (Vasey) Hitchc.

Bouteloua stricta Vasey, Bull. Torrey Club **15**: 49. 1888.

The type was collected in western Texas by Nealley. The spikes are 4 to 6, usually ascending or appressed.

Zizania texana Hitchc., sp. nov.

Perennis; culmi a basi longe decumbentes; laminae elongatae, 3–13 mm. latae; panicula angusta, 20–30 cm. longa, ramis inferioribus ascendentibus, 5–10 cm. longis; spiculae masculae 7–8 mm. longae, 1.5 mm. latae; spiculae foeminae circa 1 cm. longae, 1 mm. latae, arista 1–2 cm. longa.

Plant perennial; culms comparatively slender, long-decumbent and rooting at base, 1 to 1.5 meters long (or even as much as 3 meters), the lower part with leaves often floating on the water, the upper part erect; sheaths striate; ligule membranaceous, acute, 5–10 mm. long; blades elongate, flat, glabrous, slightly scabrous on the margins, 3 to 13 mm. wide (mostly less than 1 cm.), the uppermost blade 15 to 20 cm. long; panicle erect, narrow, mostly 20 to 30 cm. long, the lower (staminate) branches ascending or somewhat spreading, slender, 5 to 10 cm. long in about 3 whorls, woolly-villous at the base; upper branches (pistillate) appressed; staminate spikelets 7 to 8 mm. long, about 1.5 mm. wide, abruptly acute; pistillate spikelets about 1 cm. long, 1 mm. wide, terete, sulcate, scabrous on the ridges, gradually narrowed into a very scabrous, somewhat flexuous awn 1 to 2 cm. long.

Type specimen in the U. S. National Herbarium, no. 1,537,174, collected at San Marcos, Texas, in running water, April 1932, by W. A. Silveus (no. 518).

This species was also collected at San Marcos by Nealley in August 1892. Mr. Silveus writes concerning this grass:

"I found in the San Marcos River at San Marcos, Texas, a great amount of this grass growing in water 1–6 feet deep, often in swiftly flowing currents, the culms and long blades mostly floating on or some distance under the surface of the water. The culms, sometimes 10 feet long, finally bend upwards at or near the surface of the water, the erect or ascending portion bearing an unusual and beautiful panicle 1–3 feet above the water. The branching culms, often geniculate at the base, root at the nodes, especially those near the base and at the bend near the surface of the water. It is claimed that cattle have been seen sticking their heads deep in the water to get this grass. Did not find any of it growing away from the water."

Trichachne hitchcockii (Chase) Chase.

Valota hitchcockii Chase, Proc. Biol. Soc. Washington **19**: 188. 1906.

Trichachne californica (Benth.) Chase.

Panicum californicum Benth. Bot. Voy. Sulph. 55. 1840.
Panicum saccharatum Buckl. Prel. Rep. Geol. Agr. Surv. Tex. App. 2. 1866.
Trichachne saccharata (Buckl.) Nash in Small, Fl. Southeast. U. S. 83. 1903.
Valota saccharata (Buckl.) Chase, Proc. Biol. Soc. Washington **19**: 188. 1906.

The type specimen of *Panicum californicum* from Magdalena Bay, Lower California, was examined in the Kew Herbarium. Under the International Rules *Valota* was not effectively published by Adanson, the few characters in his table being inadequate. *Trichachne* Nees thus becomes the valid name.

Digitaria runyoni Hitchc., sp. nov.

Perennis; culmi ascendentes a basi longe decumbentes, 40–70 cm. alti; vaginae superiores glabrae, inferiores villosae; laminae planae, 3–6 mm. latae, superiores glabrae, inferiores dense villosae; racemi 5–10, suberecti, 7–12 cm. longi, rachi trigona; spiculae pallidae, imbricatae, anguste lanceolatae, acutae, 3.5–4 mm. longae; gluma prima minuta vel obsoleta; gluma secunda et lemma sterile aequalia, dense villosae; lemma fertile acuminatum quam spicula paullo brevius, maturitate pallidum.

Perennial; culms spreading at base, sometimes long-decumbent and rooting, 40 to 70 cm. tall, leafy at base; upper sheaths glabrous, the lower pilose, the lowermost densely villous; ligule 1 to 2 mm. long; blades flat, the lower densely velvety-villous, the upper sparingly pilose or glabrous, mostly less than 10 cm. long, 3 to 6 mm. wide, the uppermost reduced; racemes 5 to 10 on an axis 1 to 4 cm. long, mostly suberect, 7 to 12 cm. long, pale, the rachis flat-triangular, the margin very narrow, scabrous; spikelets in pairs, imbricate, narrowly lanceolate, acute, 3.5 to 4 mm. long, the longer pedicel 2 to 3 mm. long; first glume minute or obsolete; second glume and sterile lemma equal, from sparsely to densely villous on the internerves, the hairs purplish, sometimes nearly 1 mm. long, the lemma glabrous on the middle internerves, 5-nerved, the glume 3-nerved; fertile lemma acuminate, usually a little shorter than the spikelet, pale at maturity.

Type in the U. S. National Herbarium, no. 1,468,080, collected on sand flats near the coast at the mouth of the Rio Grande, near Brownsville, Texas, April 21, 1929, by Robert Runyon (no. 188).

Collected also on sand dunes 15 miles south of Corpus Christi by W. A. Silveus (no. 356), on sandy prairie, 10 miles south of Corpus Christi by J. R. Swallen (no. 1829½), and in sand at Copano Bay (east side) by B. C. Tharp (no. 7908).

Eriochloa gracilis (Fourn.) Hitchc.

Helopus gracilis Fourn. Mex. Pl. **2**: 13. 1886.

This species has been referred to *Eriochloa acuminata* (Presl) Kunth of Mexico. A weed in fields, western Texas to southern California, south through the highlands of Mexico. Originally described from Oaxaca, Mexico.

Eriochloa gracilis var. **minor** (Vasey) Hitchc.

Eriochloa punctata var. *minor* Vasey, Contr. U. S. Nat. Herb. **3**: 21. 1892. Texas to Arizona.

Andropogon divergens (Hack.) Anderss.; Hitchc.

Andropogon scoparius subsp. *maritimus* var. *divergens* Hack. in DC. Monogr. Phan. **6**: 385. 1889.
Andropogon divergens Anderss.; Hack. loc. cit. as synonym of *A. scoparius* subsp. *maritimus* var. *divergens*, "*A. divergens* Anderss. in sched. h. berol."

The locality given by Hackel is, "Texas (leg.?; vidi in h. berol.)." The type in the Berlin Herbarium is labeled "*Andropogon divergens* Anderss. [in Andersson's script]. Texas. dd. Lindley."

This case is like that of *Triodia buckleyana*, discussed above.

Andropogon virginicus var. **hirsutior** (Hack.) Hitchc.

Andropogon macrourus var. *hirsutior* Hack. in DC. Monogr. Phan. **6**: 409. 1889.

BOTANY.—*New grasses from the United States, Mexico, and Central America.*[1] JASON R. SWALLEN, Bureau of Plant Industry.

In the course of identifying several collections of grasses, eight species were found to be new. The first is a *Stipa* collected by Hans Wilkens in the Guadalupe Mountains, New Mexico. Two species, one of which is a very distinct *Echinolaena*, the second of this genus, were found by Paul Weatherwax in Guatemala. A new *Axonopus* and a new *Mesosetum* were discovered by H. H. Bartlett in British Honduras.[2] The *Mesosetum* was originally described as *Peniculus angustifolius* Swallen. In earlier collections, there were three other new species of *Axonopus*, one found at Vera Cruz, Mexico, by A. S. Hitchcock, one at Morelia, Mexico, by Brother G. Arsène, and the last at Izabal, Guatemala, by S. F. Blake.

Stipa curvifolia Swallen, sp. nov.

Culmi dense caespitosi, erecti, 33 cm. alti; folia basi aggregata; vaginae scaberulae, inferiores dense pubescentes; laminae involutae, maximae 18 mm. longae, scaberulae vel glabrae, curvatae; panicula 7–8 cm. longa, densa, ramis appressis; glumae subaequales, acuminatae, 10 mm. longae, 3-nerves, marginibus hyalinis; lemma 5.5 mm. longum, fuscum, pilosum, callo pungenti dense piloso; arista 22–25 mm. longa, 1-geniculata, infra geniculum plumosa.

[1] Received August 14, 1933.
[2] These two grasses were collected on an expedition of the Herbarium and the Museum of Zoology, University of Michigan, collaborating with the Department of Historical Research, Carnegie Institution of Washington, in a biological survey of the Maya area.

Culms densely tufted, erect, 33 cm. tall; leaves clustered toward the base, the sheaths scaberulous, the lowermost densely pubescent, the blades firm, involute, as much as 18 mm. long, becoming curled with age, scaberulous or nearly smooth; panicles 7–8 cm. long, dense, the branches short and appressed; glumes subequal, acuminate, 3-nerved, 10 mm. long, the first broader than the second, the tips and margins hyaline; lemma 5.5 mm. long, light brown, evenly pilose with white hairs, the callus sharp-pointed, densely hairy; awn once or obscurely twice-geniculate, 22–25 mm. long, twisted and densely plumose below the bend, the terminal segment straight, scabrous.

Type in the U. S. National Herbarium, no. 1,538,063, collected in crevices of limestone cliff near mouth of North Fork of Rocky Arroyo, Eddy Co., Guadalupe Mountains, New Mexico, April 29, 1932, by Hans Wilkens (no. 1660).

This species is probably most closely allied to *S. occidentalis* Thurb., which differs in having straight blades, panicles 10–20 cm. long, lemmas 7 mm. long, and twice-geniculate awns, 3–4 cm. long.

Echinolaena gracilis Swallen, sp. nov.

Culmi graciles, ramosi, pilosi, 75–90 cm. longi; vaginae papilloso-hispidae vel glabrae, marginibus ciliatis; laminae maximae 3.8 cm. longae, 5 mm. latae, planae, firmae, marginibus cartilaginosis basi papilloso-ciliatis; ligula pilosa 1 mm. longa; racemi maximi 1.8 cm. longi; spiculae 8–11 mm. longae; gluma prima acuminata, 8–11 mm. longa, tuberculata vel tuberculato-hispida, marginibus ciliatis; gluma secunda 6 mm. longa, acuta, supra papilloso-hispida; lemma sterile 5 mm. longum glumae secundae simile; lemma fertile 3.5 mm. longum, pallidum, nitidum.

Culms very slender, wiry, branching, 75–90 cm. long, appressed-pilose; sheaths of the main culm much shorter than the internodes, papillose-hispid, the margins ciliate; blades as much as 3.8 cm. long, 5 mm. wide, some of those on the secondary branches much reduced, flat, firm, pubescent or pilose above, glabrous beneath, the margins white-cartilaginous, more or less papillose-ciliate toward the base; ligule hairy, not more than 1 mm. long, sometimes scarcely evident; racemes somewhat exserted, not more than 1.8 cm. long, subtended by an acute ciliate bract about 3 mm. long, the rachis terminating in a spikelet; spikelets 8–11 mm. long; first glume 8–11 mm. long, that of the terminal spikelet much longer than the others, acuminate, strongly nerved, tuberculate or tuberculate-hispid, the margins ciliate; second glume 6 mm. long, acute, papillose-hispid at the summit; sterile lemma 5 mm. long, similar to the second glume, inclosing a well developed palea; fruit 3.5 mm. long, smooth, shining, narrowly winged below, the base fashioned into a conspicuous circular crown.

Type in the U. S. National Herbarium, no. 1,538,066, collected on open marshy prairie, near Los Amates, Guatemala, March 3, 1932, by Paul Weatherwax (no. 1601).

Echinolaena inflexa (Poir.) Chase,[3] the only other species of this genus in the American tropics, differs from *E. gracile* in having much more robust

[3] Proc. Biol. Soc. Wash. **24**: 117. 1911.

glabrous culms, exserted racemes as much as 4 cm. long, and slightly larger fruits, 3.5–4.5 mm. long.

Axonopus ciliatifolius Swallen, sp. nov.

Culmi dense caespitosi, e rhizomatibus erecti, 50–70 cm. alti; folia basi aggregata; vaginae carinatae, sparse pubescentes; laminae planae, 7–16 cm. longae, 1–2 mm. latae, pilosae, marginibus ciliatis; ligula 0.1 mm. longa; racemi 2–5, subdigitati, adscendentes vel appressi, 3–11.5 cm. longi; spiculae 2–2.3 mm. longae, glabrae vel sparse pubescentes; gluma secunda obtusa lemma sterile aequans; lemma fertile fuscum, nitidum.

Culms densely tufted, erect from short scaly rhizomes, 50–70 cm. tall, with terminal and axillary inflorescences; leaves mostly crowded toward the base, the sheaths keeled, sparsely pubescent, the blades flat, 7–16 cm. long (or those on the innovations sometimes longer), 1–2 mm. wide, pilose on both surfaces, the margins papillose-ciliate, especially toward the base; ligule 0.1 mm. long; racemes 2–5, racemose, ascending or appressed, 3–11.5 cm. long; spikelets 2–2.3 mm. long, glabrous or sparsely pubescent, the second glume and sterile lemma subequal, obtuse, scarcely covering the fruit; fruit dark brown, smooth and shining.

Type in the U. S. National Herbarium, no. 1,503,594, collected at Mountain Pine Ridge, El Cayo District, British Honduras, February 25, 1931, by H. H. Bartlett (no. 11746).

This species is distinguished from *A. purpusii* (Mez) Chase, to which it is closely related, by the presence of the well developed scaly rhizomes.

Axonopus rhizomatosus Swallen, sp. nov.

Culmi caespitosi, e rhizomatibus erecti, 45–85 cm. alti, nodis dense pubescentibus; vaginae carinatae, glabrae vel pilosae; laminae planae, maximae 25 cm. longae, 1–4 mm. latae, scaberulae, basi pilosae, marginibus papilloso-ciliatis, inferiores reductae; ligula 0.1–0.2 mm. longa; racemi 2–4, patentes, subdigitati, 5–13 cm. longi; spiculae 2.5–3 mm. longae pilosae; gluma secunda acuta, quam spicula longior; lemma sterile acutum glumam secundam aequans; lemma fertile pallidum.

Culms, caespitose, erect from short scaly rhizomes, 45–85 cm. tall, the nodes densely pubescent; sheaths keeled, rather densely pilose, especially on the collar, or nearly glabrous; blades flat, as much as 25 cm. long, 1–4 mm. wide, the uppermost reduced, not over 2 cm. long, sometimes nearly wanting, smooth or scaberulous, more or less pilose toward the base, the margins papillose-ciliate for a short distance at the base; ligule 0.1–0.2 mm. long, racemes 2–4, appressed, 5–13 cm. long, subdigitate with one a short distance below the others; spikelets 2.5–3 mm. long; second glume and sterile lemma equal, acute, slightly exceeding the pale or lead-colored fruit, the margins densely pilose, especially toward the summit.

Type in the U. S. National Herbarium, no. 1,013,859, collected on open hillsides wooded with pine, along trail from Los Amates to Izabal, Department of Izabal, Guatemala, May 13, 1919, by S. F. Blake (no. 7766).

Open pine woods, Guatemala, Honduras, and British Honduras.

GUATEMALA: Los Amates to Izabal, *Blake* 7748, 7766, 7767; Secanquim, *Pittier* 214.

BRITISH HONDURAS: Without locality, *Dunlap* in 1920.

HONDURAS: La Florida, *Blake* 7424; Siguatepeque, *Standley* 53611.

Closely allied to the preceding species, but differing in having densely pubescent nodes, larger spikelets with acute rather than obtuse second glume and sterile lemma, and pale instead of brown fruit.

Axonopus multipes Swallen, sp. nov.

Stoloniferus; culmi geniculato-adscendentes, 15–25 cm. alti, glabri, nodiis pubescentibus; vaginae carinatae, compressae, glabrae, superiores elongatae; laminae planae, obtusae, 3–6 cm. longae, 4–8 mm. latae (superiores reductae, 1 cm. longae), glabrae, marginibus basi papilloso-ciliatis; ligula brevis erosa; racemi 2, 3–5 cm. longi, conjugati; spiculae acutae, 3 mm. longae; gluma secunda lemma sterile aequans, quam lemma fertile longior, marginibus pilosis; lemma fertile 2.2–2.3 mm. longum, apice dense pubescens.

Culms geniculate, ascending from stolons, 15–25 cm. tall, glabrous or the nodes pubescent; sheaths compressed, keeled, glabrous, the upper ones elongated, inclosing some of the racemes bearing cleistogamous spikelets; prophyllum 3.5 cm. long; blades flat, obtuse, 3–6 cm. long, 4–8 mm. wide, the uppermost reduced, scarcely more than 1 cm. long, glabrous on both surfaces, the margins papillose-ciliate toward the base; ligule very short, minutely erose; racemes 3–5 cm. long, in pairs, conjugate at the summit of slender peduncles, these 3–10 cm. long, 3–5 of them arising from just above the uppermost node; spikelets acute, 3 mm. long, just reaching the one above in the same row; second glume and sterile lemma equal, exceeding the fruit, the margins and often the internerves silky-pilose; fertile lemma 2.2–2.3 mm. long, minutely cross-wrinkled, densely pubescent at the apex.

Type in the U. S. National Herbarium, no. 928824, collected on sandy prairie, Veracruz, Mexico, Aug. 31, 1910, by A. S. Hitchcock (no. 6578). Also collected at Veracruz by Gouin (no. 25).

Axonopus obtusifolius (Raddi) Chase is allied to this species, but differs in having fewer, racemose racemes and acuminate spikelets 5 mm. long, the second glume and sterile lemma much exceeding the fruit.

Axonopus arsenei Swallen, sp. nov.

Culmi caespitosi, erecti, 40–90 cm. alti, nodis dense hispidis; folia basi aggregata, 1 vel 2 caulinis exceptis; vaginae compressae, carinatae, basi papilloso-hispidae, glandulosae, marginibus ciliatis; laminae planae, 10–18 cm. longae, 5–10 mm. latae (superiores reductae), papilloso-hispidae, marginibus ciliatis; ligula brevis erosa; racemi 2–4, 5–10 cm. longi, racemosi; spiculae acutae, 3.4–3.8 mm. longae; gluma secunda acuta, pilosa, lemma sterile aequans, quam lemma fertile longior; lemma fertile 2.8 mm. longum, apice sparse pubescens.

Culms tufted, erect, 40–90 cm. tall, the nodes densely appressed-hispid with ascending hairs, otherwise glabrous; leaves crowded toward the base, the culms with only one or two above the basal ones; sheaths strongly compressed, keeled, those of the culm leaves shorter than the internodes, papillose-hispid and glandular at the base, the margins more or less ciliate toward the summit, otherwise glabrous or sparsely pilose; blades flat, 10–18 cm. long, 5–10 mm. wide, the uppermost reduced, sometimes only 3 cm. long, more or less papillose-hispid on both surfaces, the margins papillose-ciliate, especially toward the base; ligule very short, erose; peduncles 1–3 from the uppermost sheath (rarely from the lower) the terminal one elongate, the

others mostly inclosed in the sheath; racemes 2–4, 5–10 cm. long, the upper two conjugate, the others 10–20 mm. distant; spikelets acute, 3.4–3.8 mm. long, 5–7 mm. distant in each row of the raceme; second glume and sterile lemma acute, equal, exceeding the fruit, rather densely pilose between the nerves; fruit 2.8 mm. long, minutely roughened, with a few short hairs at the summit.

Type in the U. S. National Herbarium, no. 1,000,427, collected at Loma Santa María, vicinity of Morelia, Michoacán, Mexico, alt. 2,050 meters, Sept. 17, 1910, by Brother G. Arsène (no. 6952). *Arsène* 2919 and 7016, from the same locality, also belong to this species.

Allied to *A. multipes*, but differing in being a much larger plant with long-exserted primary peduncles and only 1 or 2 secondary ones, short-exserted or inclosed in the sheath, and larger spikelets and fruit.

Panicum guatemalense Swallen, sp. nov.

Culmi 75 cm. alti, scaberuli, sparse papilloso-pilosi, ramosi; vaginae glabrae vel sparse papilloso-pilosae, collo dense pubescente; laminae planae, 7–12 cm. longae, 4–10 mm. latae, scaberulae, sparse papilloso-pilosae, marginibus cartilaginosis scabris; ligula membranacea, 0.2 mm. longa; panicula 10 cm. longa, ramis adscendentibus vel appressis e basi floriferis; spiculae 2.2–2.4 mm. longae, appressae, pedicellis quam spiculis brevioribus; gluma prima obtusa, 0.5–1 mm. longa; gluma secunda lemma sterile aequans; lemma fertile 2 mm. longum, nitidum, apice pilosum.

Culms more than 75 cm. tall, scaberulous, sparsely papillose-pilose, much branched above; sheaths glabrous, papillose or papillose-pilose, those of the main culm much shorter than the internodes, those of the branches overlapping, the collar densely pubescent; blades flat, 7–12 cm. long, 4–10 mm. wide, scaberulous, more or less papillose or papillose-pilose, densely pilose on the upper surface at the very base, the white-cartilaginous margins distinctly scabrous; ligule membranaceous, about 0.2 mm. long; panicle 10 cm. long, the branches ascending or appressed, spikelet-bearing from the very base or nearly so; spikelets glabrous, 2.2–2.4 mm. long, appressed, the pedicels shorter than the spikelets; first glume obtuse, 0.5–1 mm. long; second glume and sterile lemma equal, inclosing the fruit; fertile lemma 2 mm. long, shining, sparsely hairy toward the summit.

Type in the U. S. National Herbarium, no. 1,538,064, collected in mountains near Santa María, just south of Quezaltenango, Guatemala, March 25, 1932, by Paul Weatherwax (no. 1689).

This species is related to *Panicum arundinariae* Trin., which differs in the more densely flowered panicle branches, which are usually naked for a short distance at the base, smaller spikelets 1.6 mm. long, and thinner, mostly shorter blades.

Peniculus angustifolius Swallen,[4] was recently described as a new genus and species, based on a collection of H. H. Bartlett (no. 11748) collected on Mountain Pine Ridge, El Cayo District, British Honduras. Mr. C. E. Hubbard of the Herbarium of the Royal Botanic Gardens, Kew, England, has suggested that it belongs in *Mesosetum*. This disposition of the species is correct and it accordingly becomes **Mesosetum angustifolium** Swallen.

[4] Amer. Journ. Bot. **19**: 581. *fig. 1.* 1932.

PALEOBOTANY.—*A new* Trichopitys *from the Carboniferous of Colorado.*[1] CHARLES B. READ, U. S. Geological Survey. (Communicated by JOHN B. REESIDE, JR.)

The remains of plants in the Carboniferous strata of western North America are so rare that it seems very desirable to record the occasional well-preserved material which is collected. In this communication an apparently new species of a genus previously unknown in this country is described from the Weber(?) formation of Colorado.

Genus TRICHOPITYS Saporta, 1875[2]

Trichopitys whitei, n. sp.

Leaves 80 millimeters or more in length and of approximately the same breadth, obtriangular in outline, dissected into narrow, linear lobes; base narrowly cuneate, lamina expanded rapidly into several times dichotomous lobes. Primary lobes 2 millimeters in breadth, soon bifurcating into slightly narrower, subequal laminae which fork at least once and probably twice to acutely pointed terminations. Nervation of two basal veins dichotomizing to supply the distal lobes with one to three heavy, deeply imbedded, evenly spaced veins. Texture coriaceous; lobes thick and rounded in cross-section.

Collected by J. H. Johnson, C. D. Hier, and the writer from the Weber (?) formation about 100 feet above the base, about 3 miles east of Leadville, Colo., on the west face of Evans Peak.

This species is named in honor of the American paleobotanist, Mr. David White.

Figure 1 is a photograph of a well-preserved specimen of *Trichopitys whitei* as it occurs on a thin slab of shale. The most striking features are the nearly regular dichotomies, the short base, and the modified obtriangular outline. The apices of the ultimate lobes have been restored from another specimen. It will be noticed that they are very acute. In comparison with European species of the genus, *Trichopitys whitei* is small and also shows a marked departure in having a short base.

In the enlargment of the specimen described above one may discern the details of venation. The vascular system dichotomizes with the leaf so that the ultimate lobes carry one to three veins. An important feature which the figures fail to bring out clearly is the biconvex or rounded cross-sectional shape of the segments. This is similar to the shape of recent coniferous leaves and may be a xerophytic adaptation.

Concerning the generic identification there can be little question. The only other well-founded Paleozoic genus which allows close comparison is *Dicrano-*

[1] Published by permission of the Director of the U. S. Geological Survey. Received June 17, 1933.

[2] SAPORTA, G. de. *Sur la découverte de deux types nouveaux des conifères dans les schistes permiens de Lodève (Hérault).* Comptes Rendus, **80**: 1020. 1875.

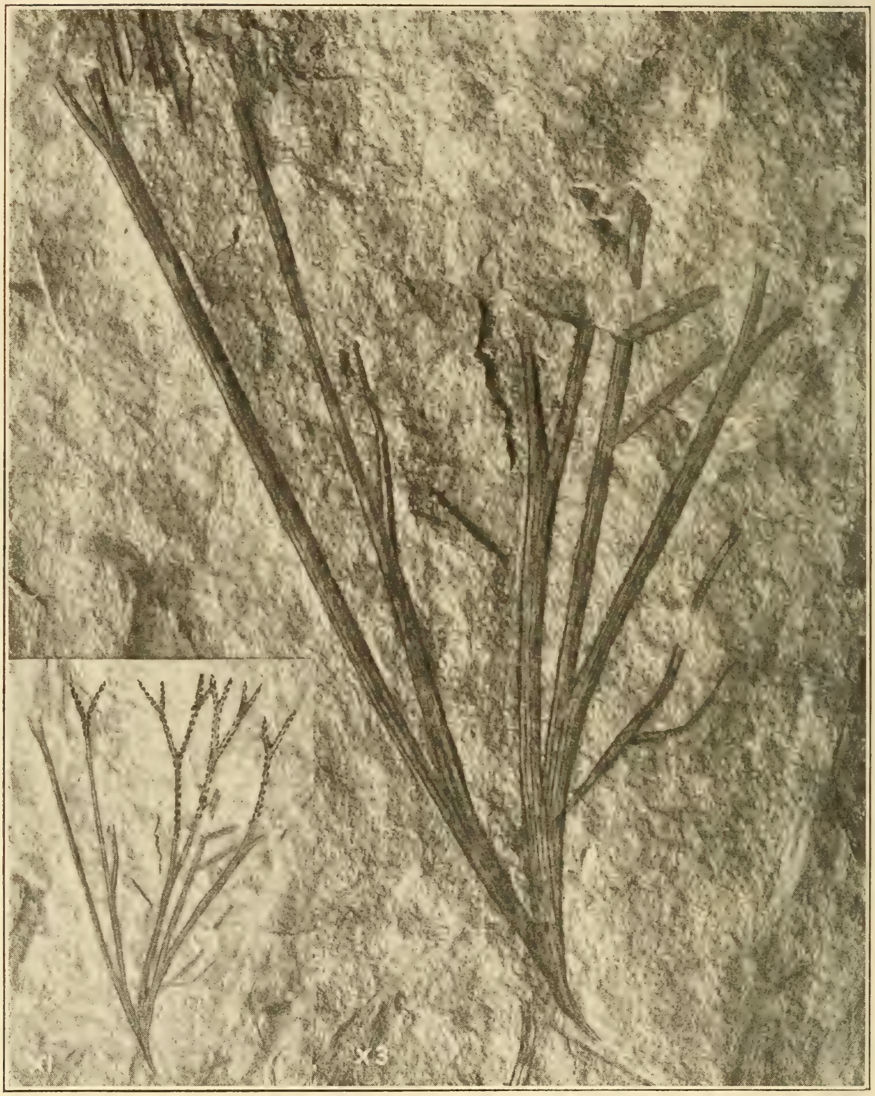

Figure 1.—*Trichopitys whitei* n. sp. showing the general appearance and details of venation, ×1 and ×3.

phyllum Grand'Eury.[3] As contrasted with *Trichopitys* this genus is characterized by smaller, more rigid, and more equally dichotomous leaves, so that a nearly perfect bilateral symmetry is produced. In addition there are features of the fructifications and of the arrangement of sterile leaves on the stem which distinguish the two. Unfortunately, such materials have not been available in the present case.

No described species of the genus are very close to *Trichopitys whitei. Trichopitys millerensis* Renault,[4] from the Autun-Epinac Basin shows some resemblance but is larger and more rigid. In addition, the details of venation differ.

A very interesting similarity exists between *Trichopitys* and the Mesozoic genus *Czekanowskia.* This suggests the possibility of extreme antiquity for the Ginkgoales, and this theory receives support from several other Paleozoic genera. It is beyond the scope of this paper to discuss the problem, but it may be pointed out that the criterion of external leaf form is not sufficient basis for a definite statement concerning the stratigraphic range of the Ginkgoales. The fructifications of *Trichopitys hetermorpha* Saporta[5] do not indicate any close affinity with the ginkgophytes as the writer understands them. *Trichopitys* is more likely a pteridosperm, it would seem, although the evidence is very meager. For the present it is best to follow Arber and assign the genus to the Palaeophyllales.[6]

Concerning the age of the beds from which *Trichopitys whitei* was collected, there is a strong suggestion that it is Pottsville. A small flora was found associated and contains several species which are very characteristic of lower Pennsylvanian strata. Since this flora is discussed in full in a paper soon to be published, it is not necessary to go into the details of the correlation here. *Trichopitys whitei* affords little evidence for or against this conclusion, since the genus has a sporadic and incompletely known distribution. It ranges from the "Upper Carboniferous" through the Permian in Europe and has been reported from the Triassic.

[3] Grand'Eury, F. C. *Flore carbonifère du département de la Loire,* p. 272. 1777.
[4] Renault, B. *Bassin houiller et permien d'Autun et Épinac: Atlas,* pl. 82, fig. 2. 1893; text, p. 378. 1886.
[5] Saporta, G. de. *Sur la découverte de deux types nouveau des conifères dans les schistes permiens de Lodève (Hérault).* Comptes Rendus, **80**: 1020. 1875.
[6] Arber, E. A. N. O. *On* Psygmophyllum majus *sp. nov. from the Lower Carboniferous rocks of Newfoundland, together with a revision of the genus and remarks on its affinities.* Linnean Soc. London Trans. 7(pt. 18): 405. 1912.

ZOOLOGY.—*New mammals from Arizona, New Mexico, and Colorado.*[1] E. A. Goldman, Biological Survey.

More critical regional studies of the rodent genera *Thomomys, Perognathus, Dipodomys,* and *Neotoma* have resulted in the segrega-

[1] Received August 24, 1933.

tion of several new geographic races. Some of these are based in part upon material collected many years ago, but it was not until additional specimens were obtained that the distinctive characters became apparent.

Thomomys alexandrae, sp. nov.

Navajo Pocket Gopher

Type.—From plain 5 miles southeast of Rainbow Lodge, near Navajo Mountain, Coconino County, Arizona (altitude 6,200 feet). No. 250969, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by E. A. Goldman, June 16, 1933. Original number 23613.

Distribution.—Vicinity of the type locality on the arid, brush-covered plains in the triangular area lying between the Colorado and San Juan rivers and Navajo and Piute creeks, in northern Arizona and extreme southern Utah.

General characters.—A small, cinnamon buffy species; skull slender in proportions; mammae in 4 pairs, pectoral 2–2, inguinal 2–2. Allied to *Thomomys fulvus aureus* of the adjoining desert region of Arizona, but decidedly smaller; color much duller, near cinnamon buff, instead of rich ochraceous tawny; cranial characters distinctive.

Color.—*Type* (summer pelage): Upper parts light cinnamon buff, purest along sides, the top of head and back somewhat darkened by black-tipped hairs; middle of face and muzzle blackish; black auricular spots conspicuous, encircling entire ears; under parts, forearms, and thighs pale ochraceous buff; feet white; tail brownish above on basal half, becoming white toward tip, and whitish below. Some of the topotypes are distinctly blackish on head. *Young* (in first pelage): Upper parts lighter, more pinkish buffy, except on face which is dusky, much as in adults.

Skull.—Similar in general to that of *T. f. aureus*, but smaller, flatter, more slender in structure; temporal ridges more widely separated; zygomata more slender, the external angle near point of union of maxilla and jugal less prominent; rostrum relatively shallower; audital bullae relatively smaller, less fully inflated; dentition relatively lighter.

Measurements.—*Type:* Total length, 210 mm.; tail vertebrae, 60; hind foot, 28. An adult male topotype: 214; 61; 28. Two adult female topotypes, respectively: 215, 205; 70, 62; 27, 28. *Skull* (type): Condylobasal length, 38.3; zygomatic breadth, 23.5; greatest breadth across squamosals (over mastoids), 18.8; interorbital constriction, 6.8; length of nasals, 13.5; maxillary toothrow (alveoli), 8.2.

Remarks.—*Thomomys alexandrae* is evidently allied to *T. f. aureus* which has an extensive range in neighboring territory, but there is no evidence of intergradation. The new species has been isolated perhaps for thousands of years by effective barriers formed by Navajo and Piute creek canyons. Bare rock walls, or cliffs, hundreds of feet in height, extend from the canyon mouths to a very narrow, rocky and sterile backbone forming a dividing line where conditions appear to be unsuitable for pocket gophers. The species is named for Miss Annie M. Alexander whose own faunal investigations and generous support of the studies by others have contributed greatly to knowledge of the mammals of western states.

Specimens examined.—Total number, 11 (2 in collection University of Arizona), all from the type locality.

Perognathus amplus jacksoni, subsp. nov.

Yavapai Pocket Mouse

Type.—From Congress Junction, Yavapai County, Arizona (altitude 3,000 feet). No. 212780, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by H. H. T. Jackson, June 21, 1916. Original number 381.

Distribution.—Desert regions of central-western and south-central Arizona, south of the range of the typical subspecies, *Perognathus amplus amplus.*

General characters.—A large, richly colored subspecies, with a broad, heavy skull. Similar in size to *Perognathus amplus amplus* of the Verde River Valley, but paler buff, upper parts less obscured by dusky hairs and cranial characters distinctive; tail slightly crested near end and tufted as in *amplus.* Larger and richer colored, the back less blackish than *P. a. pergracilis* of northwestern Arizona, and skull differing in detail. Decidedly larger than *P. a. taylori* of southeastern Arizona; color slightly paler buff, less mixed with dusky. Similar in size to *P. a. rotundus* of southwestern Arizona, but darker pinkish buff, and skull different. Distinguishable from both *P. a. cineris* and *P. a. ammodytes* of the valley of the Little Colorado River, by larger size and less dusky upper parts (contrasting strongly in color with *cineris*).

Color.—*Type* (fresh pelage): Ground color of upper parts nearly uniform pinkish buff, purest on the lateral line from cheeks across shoulders and along lower part of flanks to thighs, the top of head and back finely and rather inconspicuously lined with black; under parts, fore limbs and hind feet white; ears buffy externally, except anterior fold which is dusky, sparsely clothed internally with blackish hairs, and edged with white near posterior base; a tiny but distinct tuft of white hairs on margin of ear at anterior base; tail thinly haired, light brownish above, dull whitish below, becoming dusky on the small terminal tuft.

Skull.—Similar in size to that of *P. a. amplus,* but less flattened; mastoids narrower, less inflated posteriorly, and less bulging along line of contact with parietals; rostrum and nasals broader, less depressed anteriorly; interparietal less depressed between mastoids; audital bullae and dentition similar. Size about as in *rotundus,* but frontal region less flattened; mastoids less bulging along parietal margins; rostrum broader. Larger than *taylori, cineris,* or *ammodytes.* Compared with that of *pergracilis* the skull is considerably larger, with a relatively narrower frontal region.

Measurements.—*Type:* Total length, 168 mm.; tail vertebrae, 85; hind foot, 21. Average of four adult topotypes: 160 (152–165); 85 (81–87); 21.5 (21–22). *Skull* (type): Length (median line), 25.5; greatest breadth (across audital bullae at meatus), 15; zygomatic breadth (posteriorly), 13.3; interorbital breadth, 5.5; length of nasals, 10; width of nasals (in front of incisors), 2.5; interparietal, 2.8×2.8; maxillary toothrow (alveoli), 3.5.

Remarks.—The material upon which *Perognathus amplus jacksoni* is based has hitherto been regarded by me provisionally as referable to the typical form, *P. a. amplus.* Further study has, however, led me to believe that typical *amplus* may be restricted to the upper part of the Verde River Valley. The

recent discovery of two new subspecies, *P. a. cineris* and *P. a. ammodytes*, described by Benson (Proc. Biol. Soc. Washington, vol. 46, pp. 109–110, Apr. 27, 1933), extended the known range of the species into the Upper Sonoran Zone in the Little Colorado River Valley. Fairly well marked geographic races of *P. amplus* are more limited in distribution than is usual in most species of the genus.

Specimens examined.—Total number, 37, all from Arizona, as follows: Congress Junction (type locality), 17; Kirkland, 17; Phoenix, 1; Rice, 1; Wickenburg, 1.

Dipodomys spectabilis perblandus, subsp. nov.

Western Banner-tailed Kangaroo Rat

Type.—From Calabasas, Santa Cruz County, Arizona (altitude about 3,500 feet). No. 17748/24689, ♀ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Vernon Bailey, October 27, 1889. Original number 611.

Distribution.—Western desert region of central-southern Arizona, from the vicinity of Tucson west at least to Gunsight, and south into adjoining parts of Sonora.

General characters.—Closely allied to *Dipodomys spectabilis spectabilis* of southeastern Arizona, but smaller and paler, the upper parts more thinly mixed with black; black facial mask less distinct; tail less extensively tipped with white. Cranial characters also distinctive.

Color.—*Type* (fresh pelage): Upper parts in general light ochraceous buff, purest on cheeks, shoulders, sides, and outer surfaces of thighs, the top of head and back thinly mixed with black; under parts, postauricular and supraorbital spots, fore limbs, hind feet above, hip stripes, and tail at extreme base all around pure white; tail beyond base black mixed with gray above and below, becoming nearly black in a subterminal zone all around, abruptly interrupted by the pure white tip 40 millimeters in length, the sides white along lines narrowing gradually and disappearing in the subterminal area mentioned; soles of hind feet brownish; ears whitish externally, except anterior fold which is dusky, thinly clothed internally with minute black hairs.

Skull.—Similar to that of *D. s. spectabilis*, but decidedly smaller; mastoids relatively smaller; interparietal and supraoccipital usually actually as well as relatively broader at constriction between mastoids; dentition lighter, the incisors and molariform teeth distinctly narrower.

Measurements.—*Type:* Total length, 315 mm.; tail vertebrae, 184; hind foot, 48. Average of 10 adult topotypes: 327 (313–340); 194 (179–204); 48 (44–52). *Skull* (type): Occipitonasal length, 41; greatest breadth (between outer sides of audital bullae), 27.8; breadth across maxillary arches, 26; length of nasals, 14.9; width of nasals (in front of incisors), 4.2; least width of supraoccipital (near interparietal), 2.3; maxillary toothrow (alveoli), 5.2.

Remarks.—*Dipodomys spectabilis perblandus* is a well-marked subspecies, although not far removed geographically from *D. s. spectabilis.* It occupies the desert area west of the range of *spectabilis* which is typical in the higher plateau region of southeastern Arizona.

Specimens examined.—Total number, 44, as follows:

ARIZONA: Baboquivari Mountains (Peters Ranch), 1; Calabasas (type locality), 10; Gunsight, 2; Indian Oasis, 4; La Osa, Pima County, 7; Oracle, 6; Santa Rita Mountains (north base), 2; Tucson, 5; Tucson (30–35 miles south), 3; Tucson (75 miles southwest), 2.

SONORA: Magdalena, 2.

Dipodomys spectabilis clarencei, subsp. nov.

Northern Banner-tailed Kangaroo Rat

Type.—From Blanco, San Juan County, New Mexico. No. 158824, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Clarence Birdseye, November 19, 1908. Original number 443.

Distribution.—San Juan River Valley in northwestern New Mexico, northeastern Arizona and probably southeastern Utah and southwestern Colorado.

General characters.—Similar to *Dipodomys spectabilis spectabilis* of southeastern Arizona but larger; color usually paler and grayer, the upper parts suffused with pinkish instead of ochraceous buff; cranial characters distinctive; tail crested with black and broadly tipped with white as in *spectabilis.* Resembling *D. s. baileyi* of southeastern New Mexico in color, but black mask less distinct across middle of face, the upper surface of muzzle behind nasal pad more extensively white; skull smaller and differing in detail.

Color.—*Type* (fresh pelage): Upper parts in general near pinkish buff, purest on cheeks, shoulders, sides, and outer surfaces of thighs, the top of head and back more profusely but moderately mixed with black; under parts, postauricular and supraorbital spots, fore limbs, hind feet above, hip stripes, and tail at extreme base all around pure white; tail beyond base black mixed with gray above and below, becoming nearly pure black in a subterminal zone all around, abruptly interrupted by the pure white tip 50 millimeters in length, the sides white along lines narrowing to the subterminal area mentioned; hind legs above ankles blackish all around; soles of hind feet blackish; ears whitish externally, except anterior fold which is black, thinly clothed internally with minute black hairs.

Skull.—Similar to that of *D. s. spectabilis*, but larger; mastoids larger; maxillary arches broader and extending farther forward beyond frontals along outer side of premaxillae (as viewed from above). Compared with that of *baileyi* the skull is smaller, with a relatively broader frontal region; maxillary arches with more strongly developed external angles (tending to form more strongly projecting hooks); incisors narrower.

Measurements.—*Type:* Total length, 375 mm.; tail vertebrae, 213; hind foot, 54. Two adult topotypes, respectively: 365, 365; 204, 195; 54, 54. *Skull* (type): Occipitonasal length, 44.8; greatest breadth (between outer sides of audital bullae), 29.5; breadth across maxillary arches, 27; length of nasals, 17.2; width of nasals (in front of incisors), 5; least width of supraoccipital (near interparietal), 2.3; maxillary toothrow (alveoli), 6.1.

Remarks.—Typical *Dipodomys spectabilis clarencei* is probably restricted to the San Juan River Valley. Specimens from Gallup, New Mexico, grade toward *baileyi.* No specimens are available from Arizona but E. W. Nelson writing in August, 1909, says: "Much to our surprise we found the sandy mesa on the west side of Chin Lee Valley, from 10 to 25 miles southwest of

Chin Lee, thickly dotted with the unmistakable mounds and burrows of this species" [*Dipodomys spectabilis*]. The new form is named for the collector, Clarence Birdseye, in recognition of his notable contributions to knowledge of wild animal life.

Specimens examined.—Total number, 9, all from New Mexico, as follows: Blanco (type locality), 3; Fruitland, 4; Gallup (15 miles northwest), 2.

Dipodomys ordii evexus, subsp. nov.

Upper Arkansas Valley Kangaroo Rat

Type.—From Salida, Chaffee County, Colorado (altitude 7,000 feet). No. 150990, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Merritt Cary, November 10, 1907. Original number 1245.

Distribution.—Upper part of the Arkansas River Valley, above the Royal Gorge, south-central Colorado.

General characters.—An ochraceous buff subspecies closely allied to *Dipodomys ordii richardsoni* of the prairie region to the eastward, but tail longer, the dusky stripe on under side extending nearer to tip (usually limited to basal half in *richardsoni*), and cranial proportions, especially the smaller mastoids, distinctive. Smaller and darker than *D. o. luteolus* of the plains of Wyoming and Montana. Distinguished from *D. o. montanus* of the upper Rio Grande Valley, southern Colorado, by larger size and rich ochraceous buff coloration, the upper parts much less heavily mixed with black.

Color.—*Type* (fresh pelage): Upper parts near rich ochraceous buff, thinly mixed with black, the buffy element purest and brightest on cheeks, shoulders, flanks and outer surfaces of thighs; underparts, supraorbital and postauricular spots, fore limbs, hind feet above, and hip stripes pure white; facial mask and soles of hind feet black; ears whitish externally, except anterior fold which is dusky, thinly clothed internally with minute hairs; tail above blackish, becoming brownish at tip, below brownish along basal two-thirds beyond which the white side stripes become confluent.

Skull.—Similar to that of *richardsoni*, but basicranial region more evenly rounded above, owing to slight depression and greater breadth of interparietal and supraoccipital, and to lesser inflation of mastoids; mastoid and audital bullae smaller; maxillary arches less strongly developed; nasals shorter; incisors narrower. Distinguished from that of *luteolus* mainly by smaller size. Compared with that of *montanus* the skull is larger, more robust; mastoids less rounded and inflated; interparietal and supraoccipital relatively broader, less depressed between mastoids.

Measurements.—*Type:* Total length, 266 mm.; tail vertebrae, 149; hind foot, 42. Average of four adults from type locality: 258 (233–273); 151 (146–159); 42 (41–42). *Skull* (type): Occipitonasal length, 37.3; greatest breadth (between outer sides of audital bullae), 24; breadth across maxillary arches, 21.3; length of nasals, 13.9; width of nasals (in front of incisors), 3.8; least width of supraoccipital (near interparietal), 3; maxillary toothrow (alveoli), 4.8.

Remarks.—The differential characters of the kangaroo rats inhabiting the high valley near the headwaters of the Arkansas River were noted by me in identifying material obtained by Merritt Cary in connection with the biolog-

ical survey of Colorado many years ago. At that time, however, it seemed best to refer them to *richardsoni* and this course was followed by Cary (North Amer. Fauna No. 33, pp. 140–142, Aug. 17, 1911) who says of them: "The Salida series is not typical *P*[*erodipus*] *richardsoni*," and he further remarks in regard to the animals of the area: "The Royal Gorge, and in fact much of the Canyon of the Arkansas, would seem to prevent continuity of range from the plains." *D. o. evexus* is not very unlike typical *D. o. ordii* of western Texas in color, but is a larger, more robust animal, differing also in cranial details, and requiring no close comparison.

Specimens examined.—Seven, all from the type locality.

Dipodomys ordii cleomophila, subsp. nov.

Cinder Bed Kangaroo Rat

Type.—From 5 miles northeast of Winona, Coconino County, Arizona (altitude 6,200 feet). No. 226348, ♀ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by E. A. Goldman, July 16, 1917. Original number 23101.

Distribution.—Little Colorado Valley slopes of the Coconino and Mogollon plateaus from Flagstaff and vicinity to Springerville, eastern Arizona.

General characters.—Closely allied to and intergrading with *Dipodomys ordii longipes* of the Painted Desert region, northeastern Arizona, but upper parts distinctly darker, near cinnamon buff instead of light ochraceous buff; black facial markings more distinct; skull slightly different. Distinguished from *D. ordii chapmani* of the Verde River Valley by more robust proportions, and much richer, more rufescent coloration.

Color.—Type: Upper parts in general near cinnamon buff (Ridgway, 1912), moderately mixed with black, the buffy element purest and most intense on middle of face, shoulders and flanks; under parts, postauricular spots, fore limbs, hind feet above, usual hip stripes, and tail at extreme base all around pure white; tail beyond extreme base blackish along upper and lower median stripes to near tip where the lengthening hairs become dusky all around, the sides white to subterminal area mentioned; pencilled tip of tail inconspicuously dusky, the dark points of hairs only partially concealing the white under color; soles of hind feet blackish to toes, which are white; ears thinly clothed with short hairs, blackish internally and whitish externally, except anterior fold which is dusky; blackish facial markings broad and distinct. *Young* (in first pelage): Decidedly darker, more cinnamon buffy than in *longipes* of corresponding age.

Skull.—Essentially as in *D. o. longipes* but usually slightly smaller, with smaller mastoids, and relatively narrower maxillary arches. Much larger than that of *D. o. chapmani*, with relatively larger mastoids.

Measurements.—*Type:* Total length, 250 mm.; tail vertebrae, 149; hind foot, 41.5. Five adult topotypes: 253 (245–260); 143 (135–149); 42 (40–43.5). *Skull* (type): Greatest length (on median line), 37.5; greatest breadth (between outer sides of audital bullae), 25.2; breadth across maxillary arches, 20.5; least width of supraoccipital (near interparietal), 2.2; maxillary toothrow (alveoli), 5.

Remarks.—Like several other geographic races of small rodents inhabiting the volcanic region east of San Francisco Mountain, *D. o. cleomophila* is

characterized by relatively darker coloration. It differs from *D. o. longipes* of the adjoining Painted Desert much as *Perognathus flavus fuliginosus* and *Perognathus apache cleomophila* differ from *P. f. hopiensis* and *P. a. apache,* respectively. Specimens from Walnut Tank, 10 miles north of Angell and from Cedar Ranch Wash, a short distance west of the Little Colorado River grade toward *longipes,* but especially in the more distinct blackish markings are nearer to the new form. No intergradation is apparent with *D. o. chapmani,* which is isolated by the higher parts of the Coconino-Mogollon Plateau. The name of this subspecies is derived from that of the plant, *Cleome serrulata,* many seeds of which were found in the cheek pouches of the kangaroo rats at the type locality.

Specimens examined.—Total number, 39, from Arizona, as follows: Cedar Ranch Wash (3 miles above confluence with Little Colorado River, near Cameron), 10; Flagstaff, 1 (skull only); Tanner Tank, 2; Springerville, 7; Walnut Tank (10 miles north of Angell), 10; Winona (5 miles northeast—type locality), 9.

Dipodomys ordii nexilis, subsp. nov.

Upper Colorado Valley Kangaroo Rat

Type.—From 5 miles west of Naturita, Montrose County, Colorado. No. 149938, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Merritt Cary, July 20, 1907. Original number 1068.

Distribution.—Narrow valleys along the upper affluents of the Colorado River, the Grand, Gunnison, and Dolores rivers, in southwestern Colorado. Probably occurs also in the Colorado River Valley, southeastern Utah.

General characters.—A large, comparatively dark subspecies, with black markings well developed. Closely allied to *D. o. longipes,* but decidedly darker; black facial mask much more prominent; ears, soles of hind feet, and tail above and below more extensively black; tail with lateral white lines narrower, and dark lines correspondingly broader; cranial details slightly different. Similar in color to *D. o. cleomophila,* but larger, and still darker in tone; skull more massive.

Color.—*Type* (acquiring fresh pelage): Upper parts near cinnamon buff, purest on cheeks, shoulders, flanks and thighs, the top of head and back moderately mixed with black; under parts, supraorbital and postauricular spots, forelimbs, upper surface of hind feet, and hip stripes pure white; facial mask deep black, broad and distinct across muzzle; inner sides and anterior folds of ears blackish; soles of hind feet deep black from base of toes to heels; tail with broad blackish stripes above and below, becoming brownish all around at tip, the white lateral lines narrow—only about half the width of the dark lines.

Skull.—Very similar to those of *longipes* and *cleomophila,* but mastoid and audital bullae usually still more distended; rostrum and nasals usually slightly broader.

Measurements.—*Type:* Total length, 268 mm.; tail vertebrae, 147; hind foot, 45. Average of three adults from type locality: 271 (265–280); 148 (142–154); 45 (45–45). *Skull* (type): Occipitonasal length, 39; greatest breadth (between outer sides of audital bullae), 26; breadth across maxillary

arches, 21.3; length of nasals, 14.6; width of nasals (in front of incisors), 4.3; least width of supraoccipital (near interparietal), 2.3; maxillary toothrow, 5.2.

Remarks.—*Dipodomys ordii nexilis* probably intergrades with *longipes*, along the narrow valley of the Colorado River in southeastern Utah. Specimens from Fruita and Grand Junction are lighter buff than those from the type locality, and more closely approach *longipes* in color. In the distension of the mastoid and audital bullae, however, they are very similar to topotypes of the new form. The range of *nexilis* is separated from that of *D. o. evexus* by the high, narrow continental backbone formed by the Rocky Mountains. These subspecies of *D. ordii* contrast strongly in cranial features, especially the disparity in the size of the mastoid bullae.

Specimens examined.—Twelve, all from Colorado, as follows: Coventry, 2; Fruita, 1; Grand Junction, 4; Hotchkiss, 1; Naturita (type locality), 4.

Neotoma mexicana inopinata, subsp. nov.

Chuska Mountains Wood Rat

Type.—From Chuska Mountains, northwestern New Mexico (altitude 8,800 feet). No. 158395, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Clarence Birdseye, October 3, 1908. Original number 246.

Distribution.—Broken or mountainous areas in northwestern New Mexico, northeastern Arizona, southwestern Colorado and probably southeastern Utah.

General characters.—Similar in size to *Neotoma mexicana fallax* of the Rocky Mountains of Colorado, but color paler, and cranial characters distinctive. Distinguished from *N. m. pinetorum* of the San Francisco Mountain region, by smaller size and decidedly paler color.

Color.—*Type* (fresh autumn pelage): Upper parts light ochraceous buff, purest on cheeks, shoulders, and sides, rather thinly overlaid on top of head and over back by black-tipped hairs; under parts white, the fur basally plumbeous, except axillae and small areas on inner sides of thighs where the hairs are pure white to roots; ears dusky, narrowly edged with gray; feet white; tail sharply bicolor, brownish with a slight grayish admixture above, white below. Young individuals are paler and grayer than adults in general tone.

Skull.—Similar in size to that of *fallax*, but more angular, the basicranial ridges more prominent, and braincase less evenly rounded; frontal region narrower posteriorly, the supraorbital ridges more nearly parallel (supraorbital ridges more divergent posteriorly in *fallax*); premaxillae usually less extended posteriorly, only slightly exceeding nasals (usually reaching well beyond nasals in *fallax*); outer wall of antorbital foramen broader, reaching farther anteriorly, the antorbital notch slightly deeper as viewed from above; dentition about the same. Closely resembling that of *pinetorum*, but smaller; zygomata relatively less widely spreading.

Measurements.—*Type:* Total length, 364 mm.; tail vertebrae, 160; hind foot, 36. An adult male topotype: 360; 161; 36. *Skull* (type): Greatest length, 46.2; condylobasal length, 43.9; zygomatic breadth, 24; interorbital

constriction, 5.3; length of nasals, 19.2; length of incisive foramina, 10; length of palatal bridge, 8.5; maxillary toothrow (alveoli), 9.

Remarks.—The collection of additional specimens from Arizona in recent years has indicated the desirability of recognizing a new geographic race of *Neotoma mexicana*, with a general range as here outlined. Specimens from several localities in northwestern New Mexico and southwestern Colorado, formerly referred by me (North Amer. Fauna, No. 31, pp. 57–58, Oct. 19, 1910) to *fallax* are transferred to the new form. In color *N. m. inopinata* resembles typical *mexicana*, but is much larger and evidently more nearly related to *fallax* and *pinetorum*. It apparently intergrades with both.

Specimens examined.—Total number, 20, as follows:

ARIZONA: Tunitcha Mountains, 4 (Canyon del Muerto, 6,800, feet, 1; head of Spruce Creek, 9,000 feet, 2; Wheatfield Creek, 7,000 feet, 1); Lukachukai Mountains (8,000 feet), 1.

COLORADO: Ashbaugh Ranch, Montezuma County, 1.

NEW MEXICO: Chuska Mountains (type locality), 7; Fruitland, 2; Gallup, 2; Zuni Mountains, 3.

Neotoma micropus leucophaea, subsp. nov.

White Sands Wood Rat

Type.—From White Sands, 10 miles west of Point of Sands, White Sands National Monument, Otero County, New Mexico (altitude 4,100 feet). No. 251057, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by W. P. Taylor, May 6, 1933.

Distribution.—Known only from the dunes of whitish drifted sand in the vicinity of the type locality.

General characters.—An ashy gray subspecies, closely allied to *Neotoma micropus canescens* of the surrounding territory, but still paler; fur of under parts more extensively white to roots; ears grayer; tail brownish black, mixed with gray above (more nearly pure black in *canescens*).

Color.—*Type* (fresh summer pelage): Upper parts pale ashy gray or near pale smoke gray (Ridgway, 1912), purest on cheeks, shoulders, and sides, the top of head and back thinly mixed with black producing a finely lined effect; under parts white, the fur pure white to roots nearly everywhere except on sides of abdomen where the basal color is pale plumbeous; ears scantily haired, brownish gray externally, grayish internally; feet white; tail brownish black mixed with gray above, white below.

Skull.—As in *canescens*.

Measurements.—*Type:* Head and body (tail defective), 198 mm.; hind foot, 36. An adult male topotype: 348; 139; 34. *Skull* (type): Greatest length, 45; condylobasal length, 43.9; zygomatic breadth, 25.3; interorbital constriction, 5.9; length of nasals, 17.5; length of incisive foramina, 9; length of palatal bridge, 8.7; maxillary toothrow (alveoli), 8.9.

Remarks.—*Neotoma micropus leucophaea* is a slightly differentiated, local race probably restricted to the dunes of whitish drifted sand which, in contrast with the darker and harder soils of the surrounding country, are so

conspicuous a feature of the land surface miles in extent in Otero County, New Mexico. It is another example of the evident relation of color to environment in many mammals. Pallid coloration in this case is associated with whitish sand. The new form requires close comparison only with *canescens*.

Specimens examined.—Four, all from the type locality.[2]

[2] One in Mus. Univ. of Arizona.

ENTOMOLOGY.—*New Rutelinae (Col. lamell.) in the United States National Museum.*[1] FRIEDRICH OHAUS, Mainz, Germany. (Communicated by HAROLD MORRISON.)

In a collection of Rutelinae sent to me for naming there were the following new species, the descriptions of which I publish herewith.

Hypaspidius morio, n. sp.

Oblongo-ovatus, postice leviter ampliatus, supra et subtus unicolor niger nitidus; supra glaber, pygidio, pectore pedibusque sparsim fuscohirsutus. Clipeus oblongo-parabolicus, dense aciculatus, margine leviter elevatus. Caput, thorax et scutellum polita vix perspicue disperse punctulata. Scutellum longitudine vix latius. Elytrorum striae in disco regulares at non profundae, basin et apicem versus evanescentes, in lateribus irregulares plerumque evanescentes, interstitio subsuturali punctis nonnullis parvis. Pygidium dense aciculatum sericeum, apice et lateribus fusco-pilosum. Abdominis segmenta linea transversa punctorum piligerorum instructa, membrana inter sternitum ultimum et penultimum lata flavorufa. Sterna et coxae dense aciculata et fusco-pilosa; processus sternalis latus brevis apice rotundatus paulo declivis. Antennae fuscae. Aedeagus, Fig. 1.

Length, 25–26, breadth, 15.5–16, mm. ♂ ♀.

Locality, Venezuela: Merida.

Type and paratype, U.S.N.M. Cat. No. 43318.

Anomala (Aprosterna) quirina, n. sp.

A. cincta Say et *testaceipennis* Bl. affines. Oblongo-ovata, postice leviter ampliata, parum convexa, flavotestacea nitida, supra capita, thorace (lateribus exceptis), scutello et elytrorum margine angusto, subtus tibiis tarsisque laete viridi-aeneis; supra glabra, subtus cum pygidio sparsim flavopilosa. Clipeus cum fronte subtiliter dense rugulosa, vertex, thorax et scutellum fortius singulatim punctata; elytra regulariter seriato-punctata, punctis fortibus, seriebus vix vel non sulcatis. Pygidium punctis annularibus transversim confluentibus dense obtectum, parum nitidum, apice et lateribus solum sparsim pilosum. Abdominis sternita medio sparsim, lateribus densius confluenter punctata; metasterni latera dense confluenter punctata ac pilosa; mesosternum inter coxas intermedias latum tumidulum, at coxas non superans. Tibiae anticae tridentatae, intermediae et posticae suratae, bicarinatae. Antennae fulvotestaceae, clava concolore.

Length, 13–14, breadth, 7–7.5 mm. ♂ ♀.

[1] Received July 14, 1933.

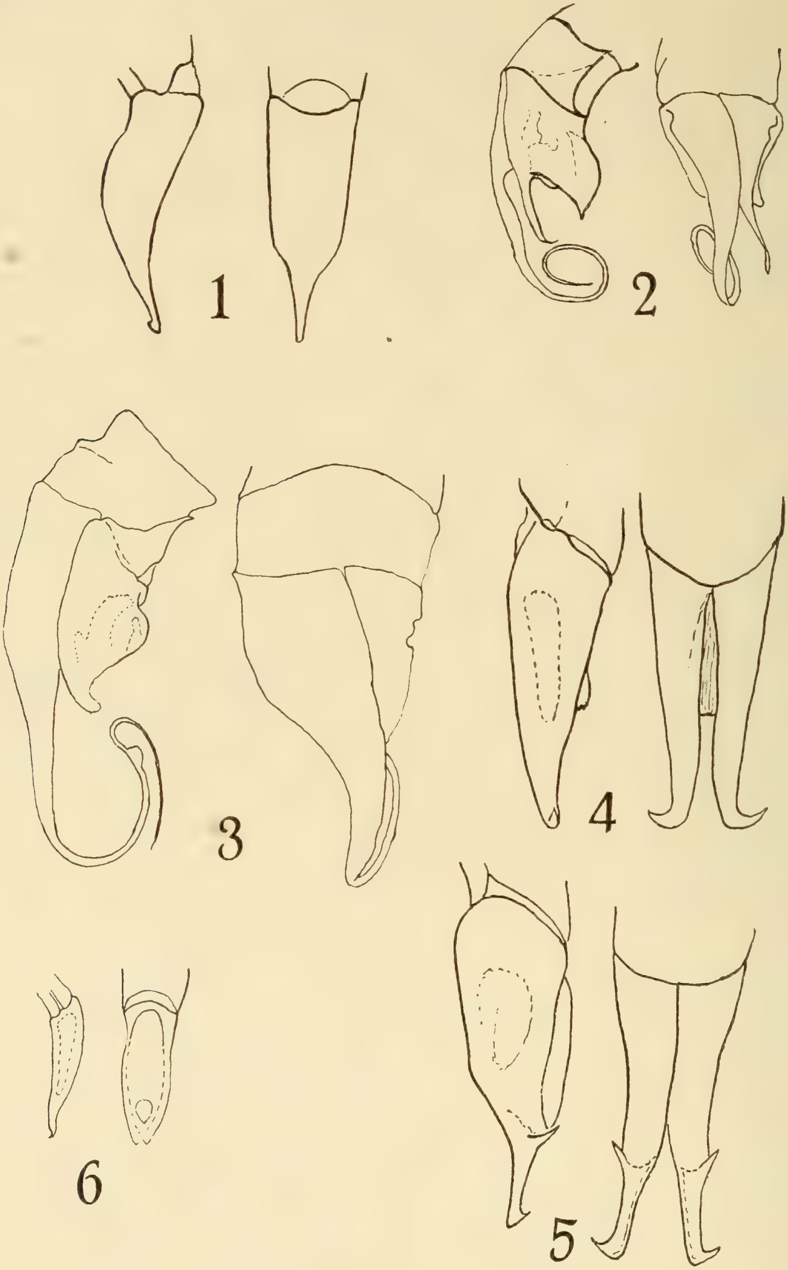

Fig. 1.—Aedeagus of *Hypaspidius morio*, n. sp. Fig. 2.—Aedeagus of *Anomala ebenina* Fairmaire. Fig. 3.—Aedeagus of *Anomala filigera*, n. sp. Fig. 4.—Aedeagus of *Anomala semicastanea* Fairmaire. Fig. 5.—Aedeagus of *Anomala rufithorax*, n. sp. Fig. 6.—Aedeagus of *Lepadoretus subcostatus*, n. sp.

Locality, Venezuela: Cumaragua, B. J. Blanco, collector.
Type and paratype, U.S.N.M. Cat. No. 43319.

Anomala flamina, n. sp.

A. championi H. Bates proxime affinis. Ovalis sat convexa, rufotestacea leviter viridiaenescens, vertice fuscoaeneo; thoracis maculis duabus discalibus, elytrorum maculis duabus pone scutellum et vittis duabus transversis, una mediana, altera praeapicali indistincta fuscis, tibiis posticis rufocupreis, tarsis omnibus fuscoviridi-aeneis. Supra cum pygidio glabra nitida, subtus cum pedibus sparsim ac breviter flavopilosa.
Length, 12–13, breadth, 6.5–7, mm. ♀.
Locality, Guatemala: Alta Vera Paz, Cacao, Trece Aguas, April 21–25, Schwarz and Barber, collectors.
Type and paratype, U.S.N.M. Cat. No. 43320.

Anomala obovata, n. sp.

A. foraminosa et *millepora* H. Bates proxime affines. Obovata, postice valde ampliata, sat convexa; supra et subtus fuscoviridi-aenea, nitida; supra glabra, pygidio sparsim, pectore densius ac longius vulpino-pilosa. Caput, thorax et scutellum sparsim ac subtiliter punctulata; elytra punctis majoribus foveolatis et rugulis transversis ornata.
Length, 19–21, breadth (greatest), 10.5–11.5, mm. ♂ ♀.
Locality, Costa Rica: Turrialba, Schildt and Burgdorf, collectors; same locality, 5500 ft., C. H. Lankester, collector; Volcan de Irazu, Staudinger; and San Jose, Underwood, collector.
Paratype, U.S.N.M. Cat. No. 43321.

Anomala perakensis, n. sp.

A. chloronota Arrow proxime affinis. Oblongo-ovata, postice leviter ampliata, supra capite, thorace scutelloque olivaceo-viridis leviter aenescens, clipei margine anteriore thoracisque lateribus flavis, elytra obscurius olivacea lateribus flavomarginata, subtus cum pedibus flava leviter aenescens, abdomine cum pygidio antennisque fulvis; supra glabra, subtus cum pedibus et pygidii margine sparsim flavopilosa. Clipeus cum fronte sat fortiter confluenter, vertex et thoracis discus minus fortiter singulatim, thoracis latera confluenter punctata. Elytra dense confluenter punctata et transversim aciculata, lineis punctorum majorum 6–7 seriatis perspicuis. Pygidium et abdominis latera subtiliter confluenter punctata et transversim aciculata. Metasternum et femora intermedia dense strigosa et flavopilosa.
Length, 13, breadth, 7.5, mm. ♀ ♂.
Locality, Perak: Trong, W. L. Abbott, collector.
Type and paratype, U.S.N.M. Cat. No. 43322.

The shape of the aedeagus is very similar to that of *A. chloronota* Arrow (Faun. Brit. India, Col. lamell., part II, 1917, Pl. 2, Fig. 5), but the apex of each paramere is less rounded and somewhat toothed at the inner edge.

ANOMALA EBENINA Fairmaire

This is one of the most variable species of the genus, showing nearly all degrees of passing from black to yellow. As the species is very common in

the southern provinces of China, Yunnan and Tonkin, I could examine some hundred specimens and found that all these color varieties are individual and not limited to certain localities. It therefore seems useless to name these varieties and I only wish to show the passing from black to yellow on the various parts of the body.

Head: generally pure black, even in specimen yellow above; only one ♀ has 2 yellow spots on the vertex.

Thorax: (1) pure black, (2) black with metallic green reflections, (3) black with a narrow yellow border at the sides alone, (4) that border broadens before and behind the lateral groove, which at first is connected with the large discal spot, until this diminishes more and more, so that finally (5) the thorax is pure yellow.

Scutellum: is always black, even in the clearest specimen.

Elytra: (1) pure black or black with faint green lights, (2) black with a small yellow spot in the middle, (3) this spot increases to a pointed transverse yellow band, (4) this band extends to the base alone, so that the foremost half is yellow, the hind half black, or (5) it extends in the apical direction alone, so that the foremost half is black, the hind half yellow, (6) the yellow extends in longitudinal stripes, beginning from the lateral margin, so that the suture and hind border alone are black, or the base and shoulders alone are black, finally (7) the whole elytra are yellow.

Propygidium: (1) black, (2) black with a small yellow spot in the middle, (3) pure yellow.

Pygidium: (1) black, (2) black with two yellow spots on the disc, (3) these spots extend more and more until there remain only three small black spots, one at the apex, one in each anterior corner. I have not yet seen specimens of pure yellow color without these black spots.

Abdomen: generally pure black; rarely yellow spots occur at the sides of the sternites or in the middle of the penultimate sternite; the sterna (pro-meso- and metasternum) are always black.

Legs: mostly black; rarely the anterior border of the femora, the inner border of the anterior tibiae and a small spot on the hind trochanters are yellow.

Antennae: (1) black, (2) the stem yellow, (3) the club, except the darkened top, also yellow.

The shape of the aedeagus, Fig. 2, of this species is very peculiar. The paramera are very asymmetrical, the right short and fine, the left much prolonged, whip-like and rolled up like the proboscis of a Sphingid butterfly.

Anomala filigera, n. sp.

A. raui Ohaus proxime affinis. Oblongo-ovata, parum convexa, supra viridi-aenea densissime confluenter punctata, subnitida, thoracis lateribus, propygidii margine posteriore et pygidii lateribus flavis; subtus cum femoribus et antennis flava leviter viridi-aenescens, tibiis tarsisque viridi-aeneis; supra glabra, subtus cum pygidii apice sparsim flavopilosa. Clipeus trapezoidal angulis rotundatis et margine anguste elevato, sutura frontali recta.

Thorax lateribus solum anguste marginatus, sine foveolis lateralibus. Elytra nec sulcata nec punctato-seriata, margine laterali paulo incrassato. Pygidium nitidum dense arcuatim aciculatum, prope angulos anteriores leviter foveolatum. Abdomen et pectus dense confluenter punctata et aciculata. Tibiae graciles, anteriores bidentatae, intermediae et posticae medio paulo incrassatae et ante apicem constrictae, posteriorum calcar superior fortiter prolongatus, quam inferior duplo fere longior.

Length, 17.5–18, breadth, 10, mm. ♂.

Locality, Sikkim: Kurseong; Assam: Shillong, 5000 ft., May 10, 1928, L. B. Parker, collector.

Paratype, U.S.N.M. Cat. No. 43323.

The shape of the aedeagus, Fig. 3, seen from dorsal and right side, is very similar to that of *A. ebenina* Fairmaire. The paramera are very asymmetrical, the right as if crippled, the left much prolonged, whip-like and somewhat rolled up.

Anomala semicastanea Fairmaire

Fairmaire described this species in Ann. Soc. Ent. Belg., **32**: 21, 1888, from China: Kiangsi, and three years later in the same Annales redescribed it from Kiukiang, Kiangsi, as *A. castanipennis*. The species is also frequent in the province of Fokien (G. Siemssen, collector). The species is violet-blue, generally with green lights, only the elytra and abdomen are brownish-red. In the aedeagus, Fig. 4, the free symmetrical paramera bear at the top one sharp tooth. Specimens from Tonkin: Mts. Mauson (H. Fruhstorfer, collector) and Laokai (R. Vitalis de Salvaza, collector) are somewhat stouter than the typical form, above and beneath dark blue without any green lights, elytra and abdomen of a clear red. The aedeagus of these specimens is one-toothed as in the typical form. In other parts of China, especially in the southwestern provinces, but also in Shantung: Tsingtau, occur specimens which at first sight seem to be immature: above, the head and scutellum alone are violet-blue, while the thorax is as red as the elytra and abdomen; beneath, the sterna and legs are blue-violet or metallic green. In the aedeagus, Fig. 5, the paramera have two sharp teeth, one at the top, a second one at the outer side. This species, which also differs somewhat in the shape of the thorax and in the sculpture of the anal sternite, I call:

Anomala rufithorax, n. sp.

A. semicastanea Fairmaire proxime affinis. Oblongo-ovata, modice convexa, supra rubro-castanea capite et scutello solum violaceis, subtus capita, sternis pedibusque violaceis aut viridi-coeruleis aut viridi-aeneis; supra glabra nitida, subtus sparsim pilosa. Thorax ante medium dilatatus ibique foveolatus, lateribus inter dilatationem et angulos posteriores incurvis, angulis posticis paulo productis. Abdominis segmentum anale margine posteriore dense aciculatum, subopacum. Cetera sicut in *A. semicastanea*. Aedeagus, Fig. 5.

Length, 14–19, breadth, 7.5–10, mm. ♂ ♀.

Locality, China: Prov. Szechuen, Siao-lou, Se-pin-lu-tschan, Mupin;

Prov. Shantung, Kiau-tschou (in collection Ohaus). Prov. Szechuen, Mt. Omei, 4400 ft., Shin-kai-si, August, 1921, D. C. Graham, collector; south of Kuan-shien, July 5, 1924, Graham, collector; Ya-chou, May-June, 1928, Graham, collector; between Ya-chou and Mupin, June 23–26, 1929, 2000–5000 ft., Graham, collector; Suifu, June 25, Graham, collector; Prov. Nganhwei, Soo-chow, N. Gist Gee, collector (in collection U.S.N.M.).

Paratypes, U.S.N.M. Cat. No. 43324.

Lepadoretus subcostatus, n. sp.

L. griseosetosus Nonfried proxime affinis. Elongato-ovatus, modice convexus, castaneus, dense subtiliter confluenter punctulatus, subnitidus, supra et subtus pilis albidis brevibus appressis dense vestitus. Elytra subcostata, pilis in costulis alternatim condensalis et evanescentibus, in callis apicalibus longioribus erectis. Pygidium in disco fasciculo pilorum longiorum ornatum, inter discum et basin linea brevi longitudinali nuda, inter discum et apicem plaga triangulari fusca nuda instructum.

Length, 10–12.5, breadth, 5–6 mm. ♂ ♀.

Locality, Lower Burma: Rangoon (F. J. Meggitt, collector).

Type and paratypes, U.S.N.M. Cat. No. 43325.

The shape of the aedeagus, Fig. 6, is very characteristic for this species, being the only one in this group of very similar species, in which the joined paramera show an oval hole in the median line just before the apex.

ENTOMOLOGY.—*The genus* Myndus *Stal in North America.* (*Homoptera Fulgoridae*).[1] E. D. BALL, University of Arizona.

The members of this genus are usually small, fragile, more or less moth-like leaf hoppers without spines on the hind tibiae, and with the vertex long, carinate margined and narrowing anteriorly. The front is narrow above and greatly widened below where it meets the clypeus in an almost straight transverse suture. In general appearance they resemble species of *Cixius* and *Oliarus* but the hind tibiae without spines and the female abdomen terminating in typical pygofers and ovipositor instead of a large wax plate with reduced genitalia will at once separate them.

Van Duzee listed twelve species in his Catalog, three of which should probably be considered as varieties. He was in error in listing *delicatus* from "Fla"; it should have been North Carolina. Fowler in "Biologia" describes the genus *Haplaxius* with two species. The type *laevis* appears to be *Myndus pictifrons* of Stal and the other species (*frontalis*) to be equal to *sordidipennis Stal* which is probably a variety of *pictifrons* lacking the color on the elytra. *M. pictifrons* seems to be congeneric with *musivus* Germ., the European type of *Myndus*, thus

[1] Received August 5, 1933.

making *Haplaxius* a direct synonym of *Myndus*. Besides these Fowler described two new species of *Oliarus* that appear to belong to this genus. His *O. chiriquensis* by the shape of the vertex is certainly a *Myndus;* he does not show the legs but the type is a female and a glance at the pygofers will be enough to determine this point. His *O. insignior* is by the head and male genitalia another *Myndus* and by the size should be very distinct and easily recognized. Metcalf added one species. The writer is adding ten more and offering a provisional key to those available for study.

PROVISIONAL KEY TO THE AVAILABLE SPECIES

A The apical portion (at least) of elytra with definite markings, often an oblique pattern, stigmal cell often widened, more or less semi-circular, with the apical venation more or less modified to conform.

- B A definite oblique band from the stigma to the anal angle, no transverse band on front (*catalina* excepted).
  - C Shining black with white apical spots............1-*beameri* Ball
  - CC Not black.
    - D Front extremely broad at apex, the carinae margined with dark above.
      - E Clypeus smoky or black..............2-*mojavensis* Ball
      - EE Clypeus pale, a transverse band on the suture ....3-*catalinus* Ball
    - DD Front less widened below. Concolorous.
      - F A black saddle including the mesonotum....4-*yuccandus* Ball
      - FF Mesonotum saffron.......................5-*nolinus* Ball
- BB No definite oblique band on elytra. Front usually transversely banded.
  - G Face ornamented but not white with black bands at base and apex.
    - H Face with a broad (or double) black band below, a faint tawny one above.................................6-*lunatus* Van D.
    - HH Face white with a scarlet triangle at apex....7-*rubidus* Ball
  - GG Face white with a black band above and below..8-*collinus* Ball

AA Apical portion of elytra concolorous (except occasionally in *pictifrons*) the stigmal cell rarely widened.

- I Face transversely banded. *sordidipennis* Stal. *radicis*. Obst., *laevis* Fowl, *frontalis* Fowl., *delicatus* Van D. and *trunctatus* Metc.[2] } 9-*pictifrons* Stal / 10-(——————)
- II Face concolorous
  - J Vertex normal, definitely narrowing anteriorly, species normally elongate.
    - K Species green or pale golden straw.
      - L Species green or greenish.
        - M Vertex long and narrow, more than twice longer than wide, no triangular genital projection........11-*viridis* Ball

[2] All of these species have the two bands on front. It will take a special study with more material than is now available to determine the number of valid species involved, which is probably not more than two or three, of which *pictifrons* Stal is the oldest name and the rest are arranged in order of proposal.

MM Vertex broad, less than twice longer than broad, a definite genital projection in both sexes......12-*viridicatus* Ball
LL Species straw color or golden.
N Species straw color......................13-*ovatus* Ball
NN Species golden..........................14-*auratus* Ball
KK Species sordid or brownish (*pusillus* may be all pale)
O Species small, pale (southern)..........15-*pusillus* Van D.
OO Species larger (over 1 m.m. wide) darker.
P Species brown, no dark spots on venter (Rocky Mts.) ....16-*impiger* Ball
PP Species pale, margins of venter with black spots (Pacific) ....17-*occidentalis* Van D.
JJ Species stout, vertex very broad and often not narrowing anteriorly.
Q Species sordid (Var. *enotatus* Van D.) or black with a light saddle ....18-*slossoni* Ball
QQ Species golden............................19-*fulvus* Osb.

Myndus mojavensis Ball n. sp.

Resembling *lunatus* in pattern, much larger and more definitely marked, with an angularly excavated pronotum and semicircular stigmal cell. White with dark lines against the carinae on front, vertex and mesonotum and a dark pattern at the apex of elytra. Length 4.5–5 mm.

Vertex definitely narrower at apex than in *lunatus;* front narrower at base, broader and more foliaceous at apex with a stout carina. Pronotum much longer than in *lunatus,* over half the length of the eye, deeply angularly emarginate posteriorly, while in that species it is not over one-third the length of eye, and shallowly roundingly emarginate. Elytra longer than in *lunatus,* the nervures heavily setigerous, punctured. The cubitus forking much farther back so that the cell thus formed is scarcely longer than wide, stigmal cell almost semi-circular. Male pygofers with a long slender median, brown, projection reaching to the apices of the white hammer-like plates—dorsal "hood" one-half longer than plates, its apex circular and entire.

Color, white above including front, dark smoky brown below including clypeus, the margins of abdominal segments white, front ivory, a pair of broad oblique black stripes inside the broadly elevated lateral margins above. Vertex with the disc mostly black, the lateral and base of median carinae broadly ivory. Pronotum ivory with dark brown areas behind the eyes, mesonotum with dark brown areas outside and similar stripes inside the broadly ivory lateral carinae. Elytra creamy white, an apical cloud, dark lines bordering the stigma and the ivory transverse nervures and three dark lines radiating from the base of the cloud.

Holotype ♀ allotype ♂ and 12 paratypes Mojave, Calif. June 15, 1909 and one male paratype from the same place July 1, 1931—all beaten with much difficulty by the writer from the tip "branches" of the Joshua trees (*Yucca brevifolia*) in the mountains to the north. A strikingly distinct species the writer has been trying to get time to describe for nearly a quarter of a century.

Myndus beameri Ball n. sp.

Resembling *mojavensis* with the carinae much less prominent. Front much shorter and broader, the clypeus short, tumid and lacking the foliaceous carinate margin above of that species. Elytra with the venation similar

to *mojavensis*. The cell formed by the fork of the cubitus four or more times as long as wide instead of wider than long, the nodal cell fully half longer than wide instead of semicircular as in that species.

Color, deep shining black above and below (sometimes fading out to a dark brown), an oblique dash on the stigma, two large areas in the outer apical cells, three small spots in the inner apicals and a spot at the apex of clavus ivory.

Holotype ♀ June 17 and three paratype males in June, Chiricahua Mts., Arizona. Two paratype males Huachuca Mts., June 14, 1928 (A. A. Nichol). Allotype ♂ and four pairs of paratypes, Santa Rita Mts., Arizona, July 17, 1932 taken by Dr. R. H. Beamer. Holotype and paratypes in author's collection; allotype and paratypes in Kan. Univ. collection; paratypes in U. S. Nat. Museum collection. This remarkably distinct species was taken on a young century plant by Dr. Beamer in whose honor it is named.

Myndus catalinus Ball n. sp.

Similar to *mojavensis*, smaller, elytra hyaline with dark margins and an extra apical cell. Length 4–4.5 mm. Vertex and front slightly narrower at union than in *mojavensis*, especially noticeable on the base of front. Elytra slightly narrower, the cells formed by the forking of radius and cubitus both very short, usually shorter than in *mojavensis*, the apical nervure arising from the apex of cubitus cell again forked forming an extra (eleventh) apical cell. Male terminal abdominal segment deeply excavated, over twice the depth of that in *mojavensis*, the short hammer-like plates scarcely exceeding the notch.

Color, vertex smoky or darker with the carinae light, front ivory, a pair of narrow lateral lines above and a dark crescent at apex, clypeus yellow, the tip smoky. Pronotum creamy white with a dark collar in front, mesonotum pale with two dark stripes (all dark in female). Elytra hyaline before the stigma with definite smoky margins, the longitudinal nervures white. The outer dark marginal line turning in before the stigma and expanding obliquely across the apical cells, another dark line arising back of the stigma and joining the first in the center, a line at right angles to this back to costal margin and about 5 dots on the nervures between the oblique stripes and the apex of clavus. Below, pale yellow.

Holotype ♀ Sabino Canyon near Tucson, Arizona, June 28, 1930, allotype ♂ Patagonia, Ariz. Sept. 20, 1930. Both examples were swept by the writer from vegetation at the foot of high rock faces.

Myndus nolinus Ball n. sp.

Resembling *mojavensis* in structure, pale saffron without black markings before the stigma. Length 3.4–4 mm.

Vertex much broader than in *mojavensis* with the lateral and median carinae only slightly elevated. As seen from the side the clypeus is much elevated above and angled with the lower half. The venation is similar to *mojavensis* with ten apicals. The cells at the forks of the radius and cubitus are rarely longer than wide.

Color, saffron yellow above and below, the mesonotum almost tawny, elytra hyaline before the stigma with the longitudinal nervures slightly embrowned, the claval suture and costa light. There is an oblique dash before the stigma, an oblique line arising at the apex of stigma and ending in

the ninth apical, the lines radiating from the center of this to the margin smoky brown. The nervures in the anal area are alternately ivory and dark.

Holotype ♀ allotype ♂ and seven paratypes, Williams, Ariz. July 13, 1929 and one ♀ paratype Tombstone, June 14, 1932; all taken by the writer sweeping under the margins of the clumps of bear grass (*Nolina*). The saffron color alone is quite distinctive.

Myndus yuccandus Ball n. sp.

Much smaller than *nolinus* with a still broader, blunter head. Saffron with the mesonotum and a semicolon on each elytron black. Length ♂ 3 mm.

Vertex broad almost parallel margined, slightly widening and almost conical where it joins the front without a carina. Front almost half as wide at base as at apex, where it is folicaceously expanded before joining the small and little inflated clypeus. Pronotum extremely long and only shallowly excavated posteriorly, almost parallel margined and as long as the width of the vertex. Elytra long and narrow, only slightly arcuated at base. The venation simple, the forks of radius and cubitus much longer than their width. Two apical nervures arising from the posterior margin of the cubitus cell. Apex of terminal segment of male roundingly produced over a triangular projection which is exposed only about its own width, plates broad and short with a broad obliquely rounding apex.

Color, face and below tawny or saffron unmarked, head and pronotum pale saffron or straw color, with two dark stripes on posterior portion of vertex. Mesonotum deep black with an ivory scutellar line on each side and a waxy depressed spot before the apex. Elytra subhyaline, the nervures saffron, a pair of large commas back to back against the scutellar angles and a pair of round dots beyond forming a pair of black semicolons. The first set of cross nervures white with more or less of dark margins, the second set dark with a dark cloud in the inner angles.

Holotype ♂ and one paratype male taken from *Yucca* at the Grand Canyon Bridge, Ariz., Aug. 30, 1930 by the writer. A strikingly distinct little species.

Myndus collinus Ball n. sp.

Resembling *sordidipennis*, slightly longer with a pair of dark stripes on the white mesonotal tablet and the second apical nervure dark. Length 5.5–6 mm.

Vertex as in *sordidipennis*, the front slightly broader and with the upper black markings decidedly oblique. Elytra longer and narrower, the outer anteapical longer and narrower than in that species and usually less definitely angled. Male pygofers with a smaller, narrower triangular projection and much broader and more evenly rounding plates than in *sordidipennis* where they are long and obliquely truncate. The lateral margins of the pygofers very slightly uniformly rounding while in *sordidipennis* they are acutely angled and usually black tipped.

Color of *sordidipennis* nearly, smoky brown, the face creamy with two black bands, the upper one consisting of two oblique dashes. Mesonotal tablet white with two black stripes adjacent to the median carina. Elytra milky subhyaline, the nervures smoky with dark stripes along the sutural margin to the middle, dark margins on nodal cell and the second apical dark,

a dark cloud in the inner angles emphasized on the nervures. These markings present in the males while in *sordidipennis* the male elytra are usually smoky subhyaline.

Holotype ♀ and allotype ♂, Fort Collins, Colo., July 7, 1898, and one paratype male July 2, 1898; all taken by the writer. This material was placed with *sordidipennis* until the striking difference in the shape of the pygofers was noted. When sorted on this character other differences were apparent.

Myndus rubidus Ball n. sp.

Resembling *collinus* in size and form but lighter and more definitely marked, face ivory white with a large scarlet triangle. Length 5–5.5 mm.

Vertex much narrower than in *sordidipennis* and its allies, the carinae as high and the vertex as narrow as in *catalinus*, the face longer and narrower than in either species. Elytra with the subcostaradial fork wider than its length before the nodal cell, nodal cell short and rounding, the tumid stigma occupying fully half its width.

Color, vertex creamy white, the high carinae broadly dark lined, face creamy or ivory white with a large scarlet triangle with its base on the apex of front. Pronotum pale, a dark inner circle extending out on the projection below, mesonotum dark brown, the central tablet lighter, variegated. Elytra hyaline, the nervures white, a narrow dark smoky band across the stigma to apex of clavus, emphasized on the longitudinal nervures but omitting the cross nervures, the radial fork all dark. A pale smoky band at apex emphasized on seventh apical and running in on the cross nervure. Below the legs are white with two triangular spots on the pectus shining black in sharp contrast. Tergum and venter dark, the margins light.

Holotype ♀ and two paratype females taken by the writer at Brownsville, Tex., Jan. 4, 1932. The scarlet triangle on the face alone will distinguish this pretty species.

Myndus viridicatus Ball n. sp.

Resembling *viridis*, slightly smaller, broader with a shorter vertex; bright vivid green. Length 4–5 mm.

Vertex definitely broader than *viridis*, less than twice as long as its basal width. Elytra slightly broader, the nodal cell longer, with the margin thickened equally throughout, about $2\frac{1}{2}$ times as wide as the costal nervure. Female with the last ventral segment deeply triangularly emarginate, the apex of the notch with a roundingly triangular projection. Male pygofers compressed, their lower margin produced into two dark margined triangles, from the bottom of the notch between arises a compressed projection about twice the length of the notch and bearing an elongate keel on the back; plates parallel margined as far as the median projection then broadened into elongate oblique apices clothed with long hairs.

Color, deep green in life, the eyes partly darkened, below paler green, the elytra with a trace of tawny towards the apex.

Holotype ♀ allotype ♂ and 4 ♀ paratypes Huachuca Mts. Aug. 2, 1931, one ♀ paratype Santa Catalina Mts. Aug. 15, 1931, all collected in Arizona by the writer.

Myndus ovatus Ball n. sp.

Resembling *viridicatus* but a still broader vertex and slightly longer elytra with a broad stigma. Green. Length 4.5–5 mm.

Vertex broader in front and more nearly parallel than in *viridicatus*, much broader and shorter than in *viridis*. Elytra long and slender with long apicals, the nodal cell oval with a nervure at right angles to costa in the anterior portion before which the area is thickened, beyond this nervure the margin is thickened in a curved stigma which occupies nearly half of the cell. Female segment with the base of the triangle broadly rounded without a projection, male pygofers as in *viridicatus*, the lower margins projecting slightly but only slightly sinuate. The median projection with a wider keel, the plates very slender for the length of the projection then terminating in an almost round expansion four times the width of the basal portion.

Holotype ♀ July 14, 1894, allotype ♂ June 28, 1894, both taken by the writer at Ames, Iowa. These were included as paratypes of *viridis* when that species was described, but in studying the material in comparison with *viridicatus* it was discovered that there were three distinct green species, one with triangular genital projections in both sexes (*viridicatus*), the other two lacking them but easily separated by the wide vertex and round plates in *ovatus* as against a long narrow vertex and long narrow plates in *viridis*. The holotype of *viridis* is hereby fixed on a ♀ taken by the writer at Grand Junction, Colo. July 28, 1900, and now in the author's collection.

Myndus auratus Ball n. sp.

Resembling *occidentalis* slightly longer and more slender. Golden and straw color without the dark markings. Length 5–5.5 mm.

Vertex and front similar to *occidentalis*, the elytra longer and narrower, the outer anteapical cell definitely wider than the nodal with the inner margin angled at the cross nervure to the medius, the medius forked at this point but the outer fork continuing the line of the nervure. The nodal cell long and narrow, truncate in front and rounding to costa behind, the stigma $2\frac{1}{2}$ to 3 times the width of the costa.

Female segment less deeply notched than in *occidentalis*, the male pygofers with the acute projections of that species reduced to sinuations, the styles with the inner margins nearly straight and the outer ones broadly expanded apically instead of the reverse as in *occidentalis*.

Color, golden and creamy with a trace of green on the venter, elytra golden subhyaline, the nervures concolorous, no black markings on the abdominal segments as in *occidentalis*.

Holotype ♀ allotype ♂ and six paratypes taken by the writer, Bonita Canyon, Chiricahua Mts., Ariz., July 6, 1930.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

500TH MEETING

The 500th meeting of the Society, which was also the 40th anniversary of its founding, was held in the Assembly Hall of the Cosmos Club, February 22, 1933, President C. N. FENNER presiding. The program was contributed entirely by charter members.

Program: WHITMAN CROSS.—*Reminiscences concerning the founding of the Society.*

Discussed by Messrs. KEITH and FENNER.

T. W. STANTON: *The evolution of the geologic map of the United States.*—The first geologic map of the United States is that of William Maclure published in the Transactions of the American Philosophical Society in 1809. A second edition, which was exhibited, appeared in 1817. It covers the country east of the Great Plains and follows the classification of Werner, dividing the rocks into Primitive, Transition, Floetz or Secondary, and Alluvial, with a special tint for the Triassic, which was called Old Red Sandstone.

A more modern stratigraphic classification was used by James Hall in 1843 in a map which covered the area from Hudson River to the Mississippi and as far south as the southern boundary of Virginia. Lyell's Travels in North America, published in 1845, was accompanied by a similar map.

Between 1853 and 1869 there appeared maps of North America by Edward Hitchcock and by Jules Marcou, and of the United States in whole or in part by Marcou, H. D. Rogers, Hall and Lesley, and Logan and Hall.

A geologic map of the United States by C. H. Hitchcock and W. P. Blake accompanied the report of the ninth Census published in 1872. A revised edition of this map, which is on the scale of 1 to 7,115,000, or about 110 miles to the inch, was included in Walker's Physical Atlas in 1874.

Hitchcock prepared a large wall map of the United States on a scale of 20 miles to the inch which was published by Bien in 1881.

The first general geologic map of the whole country issued by the United States Geological Survey was compiled by W J McGee with the assistance of C. H. Hitchcock, on a scale of 1 to 7,115,000 and published in 1884 with the Fifth Annual Report. It shows large blank areas in the western States. Hitchcock's map published in 1887 in the Transactions of the American Institute of Mining Engineers is a revision of McGee's map and said to have been printed from the same stones, but its appearance is different because the uncolored areas are smaller and the scheme of coloring is changed to that adopted by the International Congress at Berlin in 1885.

McGee's map of 1893 published in the Fourteenth Annual Report of the Geological Survey is a revision of his map of 1884 with many blanks filled and some changes in classification.

In preparation for the meeting of the International Geological Congress in Mexico in 1906 the United States Geological Survey, the Geological Survey of Canada, and the Instituto Geologico of Mexico cooperated in the compilation of a geologic map of North America on the scale of 1 to 5,000,000. The work was done under the supervision of Bailey Willis and an edition of 1,500 copies was printed at the expense of the Mexican Government before the meeting of the Congress. A second edition of this map, in the compilation of which Willis was aided by George W. Stose, bears the date 1911 and was issued with Professional Paper 71. It shows many changes, especially in the classification of the pre-Cambrian.

A new geologic map of the United States, on the scale of 1 to 2,500,000, or 40 miles to the inch, now in press, will be published by the Geological Survey before the Washington meeting of the International Geological Congress next summer. The eastern half and a color proof of the northwest quarter of this map were exhibited. (*Author's abstract.*)

N. H. DARTON: *Zuñi Salt Lake.*—This lake is in a large deep crater in the Cretaceous plains, about 75 miles south of Gallup, New Mexico. The crater is believed to be the product of a volcanic explosion for it has volcanic

cinder cones in its center and its rim is capped by a low ridge of rock fragments mostly volcanic but including limestone containing fossils from Carboniferous strata 800 feet or more below the surface. The crater is about a mile in diameter, nearly 200 feet deep and has walls of horizontal Upper Cretaceous sandstone capped in part by a thin sheet of lava of moderate antiquity. The shallow saline lake covering part of its bottom has furnished salt for Indians and others for many centuries. The two cinder cones near the center are about 150 feet high, and one of them has a deep crater with a small saline pond in its bottom. The rim of ejected fragmental material which covers a zone of moderate width, consists largely of scoria and fragments of lava but also much sand and scattered masses of the fossiliferous limestone above mentioned. It is known from observations in adjoining areas that some distance underground the Cretaceous sandstone is underlain by the red beds of the Chinlee and Moenkopi formations, at least 700 feet thick, which in turn are underlain by Kaibab limestone which furnished the fossiliferous fragments.

It is evident from these observations that the crater is the product of deep-seated explosion in advance of an upwelling of lava which produced the two cinder cones. Its history is similar to that of many other explosion craters[1] in this and other countries including the Afton Crater in the plains west of El Paso, various craters in the Pinacate region of northern Sonora, Mexico, and some of the numerous "Xalapagos" in central Mexico. Also a crater recently discovered in the San Bernardino lava field, 30 miles northeast of Douglas, Arizona. These great craters show the competency of explosion in connection with volcanic activity to produce such a crater as Crater Mound, (so-called "Meteor Crater") southwest of Winslow, Arizona. (*Author's abstract.*)

Discussed by Mr. Butts.

Arthur Keith: *Major structures and intrusions in New England.*—Granites are especially prominent in southern Maine, New Hampshire, and central Massachusetts, forming part of the long succession of granite bodies along the southeastern part of the Appalachian system.

Long arms marked by granite instrusions project from the principal granite region, westward to Montreal, northward through New Brunswick, and eastward through Nova Scotia. These appear to radiate from a center under the Gulf of Maine. As a whole the granites are limited by a boundary running west of north from eastern Connecticut to Montreal, P. Q., and thence N. 70° E. to the Bay of Chaleur in New Brunswick, southerly to the Bay of Fundy, and finally easterly across Nova Scotia. The apex of this wedge cuts entirely across the Appalachian System through Montreal, a relation found nowhere else, and again nearly crosses it in the Gaspé region of northeastern Quebec.

The major folds and faults of the region are continuous for hundreds of miles with parallel trends. In northern Vermont the structure trends change nearly 60°, from west of north to northeast forming the Vermont salient. This change is accompanied by a great excess of northwestward movement evidenced by thrust faults and strong folds.

An axis drawn southeastward from the Montreal granite projection and through the principal granite concentration is almost identical in position with the structural cross axis passing through the Vermont salient. At this cross axis, common to intrusions and structures, a notable arrangement of

[1] Darton, N. H., Explosion Craters, Sci. Mo., November, 1916.

sedimentary systems and pitching folds is found. For instance, Silurian rocks nowhere cross this axis although they come close to the axis in five parallel synclines which cover the entire folded belt from the St. Lawrence River to the Gulf of Maine. The same sort of thing is true for the other Paleozoic systems although they are somewhat less widespread. It is clear that the major folds pitch away from the cross axis so that the systems of the Paleozoic and pre-Cambrian deepen and widen away from it, especially to the northeast.

The intrusives are nearly all massive biotite granite, with small amounts of diorite, gabbro, syenite, and rarer holocrystalline rocks. They are treated here, not as petrographic problems, but as masses which influence structure. They range in size from plugs a fourth of a mile in diameter, through stocks of a few miles, and up to batholiths 140 miles long and 20 miles wide. The smaller masses have rather rounded outlines, but the large ones are very irregular.

Contact metamorphism is very slight, and there is no dynamic metamorphism except in a few bodies of pre-Cambrian and pre-Devonian granite.

The granitic rocks cut the youngest formations with which they are in contact, usually Ordivician, Silurian, and Devonian, both sediments and volcanics. In three regions the granites also cut Pennsylvanian strata; these are the Narragansett basin in Rhode Island, the Worcester basin in Massachusetts, and the Portland basin in southern Maine. Other areas may perhaps be found in the little explored regions of New Brunswick.

The relations of major uplift along the cross axis, of concentrated thrust to the northwest along the same axis, of concentration of intrusions in same belt, of great excess advance of magmas on the same axis, of the Pennsylvanian age of many granites, of probable similar age for most of the others, of closing Pennsylvanian age for the folds and thrusts, of visible force where intrusions have forced aside the sediments, makes a complete and coherent structural system. It is so reasonable and free from exceptions that serious consideration must be given to the theory that the intrusions were a direct cause of the structures. From this conclusion must be omitted some pre-Devonian granites in eastern Maine and eastern Massachusetts, and perhaps some post-Devonian granites in New Brunswick, as well as various pre-Cambrian granites. (*Author's abstract.*)

Discussed by Messrs. BUTTS, STOSE, and FENNER.

WILMOT H. BRADLEY, *Secretary.*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

U. S. Public Health Service studies encephalitis.—The outbreak of encephalitis lethargica centering around St. Louis has commanded much attention from the U. S. Public Health Service. A staff of investigators, under Dr. JAMES P. LEAKE, has been on the ground since the earlier stages of the epidemic. Surgeon-General HUGH S. CUMMING and Assistant Surgeon-General R. C. WILLIAMS have made visits to the area and are in constant touch with developments.

The efforts of the Public Health Service workers are bent primarily toward obtaining a better understanding of the epidemiology of the disease.

In addition to compiling a complete record of case histories, they are following all promising leads which may help toward a knowledge of the mode of transmission of encephalitis. They have procured a number of Rhesus monkeys for inoculation experiments, which have yielded results which though still somewhat equivocal are at least suggestive.

Mosquitoes as encephalitis vectors.—Strong evidence that the virus of one type of encephalitis may be carried by mosquitoes has been obtained by Maj. JAMES S. SIMMONS, Lt.-Col. RAYMOND A. KELSER and Maj. VIRGIL H. CORNELL. Their preliminary report was published in *Science* for September 15. Rabbits were used as experimental animals, and *Aedes egypti* as the carriers. The virus was of the herpes encephalitis type, probably not identical with the disease of the St. Louis outbreak. Three strains of virus were used, one of them having originated from a human case. Mosquitoes that had fed on infected rabbits were allowed to feed on uninfected animals, a large proportion of which died, some of them developing paralysis, and some showing also typical lesions in brain and spinal cord. It was further proved possible to transmit the infection by implanting brain tissue from the mosquito-infected rabbits into healthy animals.

Maj. SIMMONS and Maj. CORNELL went to St. Louis on September 4 to study the possible connection between mosquitoes and the present epidemic of encephalitis lethargica there. They were accompanied by Sgt. JESSE F. RHOADS and Sgt. GEORGE F. LUITPOLD, M.C., U.S.A., who are expert "mosquito men."

Dutch elm disease a stowaway.—Dutch elm disease, which federal and state authorities are fighting in the area around New York Harbor, came in as a stowaway in elm logs shipped from Europe for use in the manufacture of furniture veneer. Conclusive evidence to this effect was presented by R. KENT BEATTIE of the U. S. Department of Agriculture before a shade tree conference held in New York City on September 8. Although the logs are known to the trade as "Carpathian elm," they appear to come principally from central and southern France. Evidences of the disease, culturable infections of the fungus, *Graphium ulmi*, and both of the species of carrier beetles, *Scolytus scolytus* and *S. multistriatus*, have been found on logs landed at Atlantic seaports. Importers have cooperated willingly in an effort to stop fresh entries of infected beetles. On September 15 a hearing on the Dutch elm disease situation was held at the U. S. National Museum.

Weather Bureau has a busy day.—Labor Day, Sept. 4, was decreed by Secretary of Agriculture WALLACE as a complete holiday: all workers in the Department were instructed to stay away from their offices, which were to be locked up tight from Saturday noon until Tuesday morning. Two tropical storms chose just that day to strike the coasts of Florida and southwestern Texas, respectively, and the force at the Washington office of the Weather Bureau had one of the busiest working days in its history. According to C. L. MITCHELL, the simultaneous landfall of two tropical storms was unprecedented in the history of the Weather Bureau.

Radio talks.—The following radio addresses were sent out from Washington on the network of the Columbia Broadcasting System, under the auspices of Science Service: "Millionth of a Second," by Prof. J. W. BEAMS, University of Virginia; "The Poetry of the Rocks," by Dr. R. S. BASSLER, U. S. National Museum; "How Animals Spend the Winter," by AUSTIN H. CLARK, U. S. National Museum.

Office of National Parks, Buildings and Reservations.—The former National Park Service, organized as a bureau of the Department of the Interior, has now been merged in a new Office of National Parks, Buildings and Reservations. The new Office administers several classes of Government property not included in the responsibilities of the National Park Service, notably the parks and public areas in the District of Columbia.

The blazing-colored Cedar Breaks area in Utah was made a national monument by proclamation of President Roosevelt signed August 25, making a total of 51 national monuments now under the jurisdiction of the Office of National Parks, Buildings, and Reservations. The monument contains approximately 5,760 acres and was formerly a part of the Dixie National Forest.

Pinnacles National Monument, California, a reservation administered by the National Park Service, has been enlarged through considerable extension of its northeastern, northwestern and southern boundaries. A proclamation legalizing the addition was signed recently by President Roosevelt. The addition comprises 5,001.78 acres, making the total area of the monument now 9,908.39 acres, more than double its former size.

A study of the nesting grounds of the white pelican, recently made for the Office of National Parks, Buildings and Reservations by Ben H. Thompson, indicates a population of from 20,000 to 25,000 of these birds still surviving in the United States proper, plus an unknown but probably smaller number in Canada. There are now only seven known large nesting colonies, whereas there were formerly at least seventy.

Studies of diseases in game birds.—Progress in studies of upland-game-bird diseases was reported at the American Veterinary Medical Association annual meeting held in Chicago from August 14 to 18, by Dr. J. E. Shillinger of the Bureau of Biological Survey, U. S. Department of Agriculture. Losses in some species of game birds in recent years have more than offset reproduction, said Dr. Shillinger, and through disease studies the Biological Survey is aiding in the propagation of quail, pheasants, grouse, and other birds on game farms. Presenting a paper of which Dr. L. C. Morley, also of the Biological Survey, is joint author, Dr. Shillinger discussed the variety of test birds used in bureau experiments in transmitting ulcerative enteritis in quail, grouse, and other game birds. This disease, he reported, often wipes out a large part of the stock on game-bird farms, young birds sometimes dying within 48 hours after contact with a virulent strain of the infectious agent. The causative organism, he said, has not yet been grown in the laboratory in pure cultures, but postmortems indicate that it is a toxin producer as well as a cause of ulcer formation in the digestive tract. The paper described a back-yard laboratory maintained by Dr. Morley at his home in Richmond, Va. Here Dr. Morley keeps watch of nesting birds, eggs during incubation, young birds in an electric brooder, and their growth to maturity in a developing pen.

The Oil-Pollution Menace.—As a member of the Interdepartmental Committee on Oil Pollution of Navigable Waters, F. C. Lincoln, of the Bureau of Biological Survey, is representing the Department of Agriculture in a study being made of measures to deal with the oil-pollution menace on the high seas. Other members represent the Division of Western European Affairs, Department of State, which has sponsored the committee; the Bureau of the Public Health Service, Department of the Treasury; Office of

the Chief of Engineers, Department of War; Bureau of Construction and Repair, Department of the Navy; the Geological Survey, Department of the Interior; and the Bureau of Fisheries, Department of Commerce. The committee held its first meeting on August 16, at the State Department.

Department of Terrestrial Magnetism.—Dr. E. H. BRAMHALL, research associate at the Massachusetts Institute of Technology, and Dr. R. J. STEPHENSON of the University of Chicago, are spending two weeks at the Department of Terrestrial Magnetism for training in magnetic observations preparatory to field work with the Byrd Antarctic Expedition II. Dr. THOS. C. POULTER, in charge of the scientific work of this Expedition, also spent a few days at the Department discussing the proposed magnetic and cosmic-ray work to be undertaken on the Expedition.

P. G. LEDIG of the Department of Terrestrial Magnetism has made a short inland trip in Brazil obtaining determinations of the magnetic elements at Catalao, Bella Vista, and Goyaz in the state of Goyaz. He is now in Santos where he will make a series of cosmic-ray observations for Professor COMPTON before sailing for New York September 13.

Cooperative work in China under the direction of Mr. F. C. BROWN, a former observer with the Department of Terrestrial Magnetism, now connected with the American Church Mission at Hankow, China, assisted by Dr. C. T. KWEI of the Department of Physics at the Central China College at Wuchang, has been carried on during the summer in spite of civil warfare necessitating a change of itinerary. The results obtained by these observers doing part-time work as occasion offers are extremely valuable in the study of secular variation in that part of the world.

Seismograph beats telegraph.—On Friday morning, August 25, a heavy earthquake took place in the region of Chengtu in interior China. Its epicenter was given an approximate location by seismologists of the U. S. Coast and Geodetic Survey on the basis of data collected and reported telegraphically to Science Service by the Jesuit Seismological Association and numerous official and university seismological observatories. At that time the statement was made that "considerable damage and loss of life was probably inflicted on the region." Five days later, belated cable reports confirmed the information thus first obtained directly from seismological sources.

Child labor.—Prohibition of the employment of minors under 16 years of age under the National Recovery Act has given renewed emphasis to national interest in child-labor problems. The Children's Bureau has recently published, under the title *Employed boys and girls in Rochester and Utica, New York*, the latest of a series of several studies undertaken to find out the kinds of work open to boys and girls and the effect of age and education upon their occupations and the stability of their employment. The previous studies of this series were made in Newark and Paterson, N. J., and in Milwaukee, Wis. All these inquiries were made before the commencement of the general industrial depression that began in 1929, so that the facts obtained indicate the extent and nature of child employment under relatively prosperous business conditions. ALICE CHANNING, who, with HARRIET A. BYRNE, directed the field work, wrote the report of the study in Rochester and Utica, which was under the general supervision of ELLEN NATHALIE MATTHEWS, formerly director of the industrial division of the Children's Bureau.

News Briefs

The setting of commercial standards, until now an activity of the Commerical Standards Group of the National Bureau of Standards, has been relinquished to a private organization, the American Standards Association, by order of Secretary of Commerce Roper.

Dr. Thomas V. Moore, professor of psychology at the Catholic University of America, has published an important contribution to the study of mental disease in the University's "Studies in Psychology and Psychiatry." Dr. Moore makes use of a new technique in multiple correlations to analyze the occurrence of five distinguishable syndromes in the manic-depressive and dementia praecox psychoses.

George Washington University announces the following additions to its faculty: Dr. Edward Bright Vedder as professor of experimental medicine and executive officer of the department of pathology and experimental medicine; Dr. Donald B. Young as professor of zoology; and Dr. William John Cooper, formerly U. S. Commissioner of Education, as professor of education.

Sheets from the famous Mutis herbarium, housed at the Madrid Botanic Garden since the Colombian revolution of 1816, are now yielding many species new to science, though it is well over a century since they were collected. The renewed study of this collection was stimulated last year by a visit of Ellsworth P. Killip, of the U. S. National Museum, to Madrid. Duplicates have been sent to the Herbarium here, while Dr. Arturo Caballero carries on examinations in Madrid.

"Depression grave robbing" is the term applied to archaeological pot-hunting which amateurs, spurred by the hope of small monetary gains to relieve their distress, have been carrying on in Indian mounds, southwestern village sites, and other scientifically valuable spots all over the country. He appealed to property owners to prevent such vandalism, and to the diggers themselves to spare irreplaceable relics of American prehistory, whose scientific value is incomparably greater than the small cash returns they might possibly yield.

"Heavy water," containing larger than average ratios of the higher isotopes of oxygen and of hydrogen isotope 2, has been found to occur naturally in the water of crystallization in salts from Great Salt Lake and the Dead Sea, by Dr. E. B. Washburn of the U. S. Bureau of Standards. This natural "heavy water" from the Dead Sea was two parts per million heavier than ordinary water; that from Great Salt Lake three parts per million heavier.

A mosquito survey of the entire United States has been undertaken by the Medical Corps of the U. S. Army, in cooperation with the Civil Conservation Corps.

Birds, as well as man and the forests, are benefiting by the Federal unemployment relief program. Three camps of the Civilian Conservation Corps are improving refuges established and maintained by the Federal Government for the protection of birds. One of these, the Blackwater Migratory Bird Refuge, near Cambridge, Md., is a breeding ground for black ducks and blue-winged teal. Mallards and pintails also concentrate on the Blackwater

marshes during the migration season, and many shorebirds find sanctuary there. The other two refuges now being improved by the Conservation Corps are used by the birds principally during migration and in the winter season—Swanquarter Migratory Bird Refuge, in North Carolina, and St. Marks Migratory Bird Refuge, in Florida.

The extension to the Experiment Building at the Department of Terrestrial Magnetism, the Carnegie Institution of Washington, has now been completed and the installation of the two-meter Van de Graaf electrostatic generator is progressing rapidly.

Personal Items

Maj. H. A. Nisely of the Ordinance Department, U. S. Army, spoke on the mechanization of military forces before the Chicago meeting of the Society of Automotive Engineers, on August 28.

Dr. F. A. Moss of George Washington University addressed the Society of Automotive Engineers at their Chicago meeting, on August 31. He discussed a number of psychological problems connected with motor car operation.

Dr. J. W. Turrentine of the Bureau of Chemistry and Soils, U. S. Department of Agriculture, reported on progress in building up American potash production, before the meeting of the American Chemical Society in Chicago.

Dr. M. X. Sullivan and Dr. W. C. Hess of Georgetown University presented a paper before the Chicago meeting of the American Chemical Society, on a correlation between cystine deficiency in the tissues and the incidence of arthritis. They stated that injection of colloidal sulfur brought about an improvement in the condition of arthritis patients.

Dr. Paul H. Furfey, of the Catholic University of America, presented a paper before the Chicago meeting of the American Psychological Association.

C. B. Watts, senior astronomer of the U. S. Naval Observatory, who will have charge of the World Longitude operations in October-November, left the Observatory for San Diego, Calif., on September 5. J. E. Willis will join Mr. Watts on September 25.

Commander Guggenheim of the French Navy passed through Washington en route to San Diego, where he will collaborate with the Naval Observatory's party in the prosecution of some special work desired by the French government.

Dr. Thomas B. Nolan of the U. S. Geological Survey was awarded the Spendiaroff prize of the International Geological Congress in recognition of his studies in the western mining districts of United States.

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This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors before the tenth of one month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following month.

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JOURNAL
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VOL. 23 NOVEMBER 15, 1933 No. 11

CHEMISTRY.—*Notes on the occurrence of rotenone in species of* Derris *and* Lonchocarpus.[1] HOWARD A. JONES, Bureau of Chemistry and Soils. (Communicated by C. M. SMITH.)

In a recent article[2] data were given on the rotenone content of a number of samples of East Indian derris root (*Derris sp.*), South American cube root (*Lonchocarpus nicou*) and some other plants of the genus *Lonchocarpus*. Information has now been obtained on the occurrence of rotenone in the stems and leaves of derris and cube, and on the rotenone content of roots and stems of certain other South American plants.

No values are given in the literature for the rotenone content of either stem or leaf material of derris, although several investigators[3,4,5] have reported the amount of total extractives in stem parts of *D. elliptica*, *D. uliginosa* and other species of *Derris*. Blackie[6] has recently reported 0.3 per cent rotenone in a composite sample of stem and root of *D. uliginosa*, but it is uncertain whether the rotenone was contained in the stem or root portion. In the present investigation samples of the stems and leaves of both *D. elliptica* and *D. uliginosa* were examined, as well as a sample of "twigs and bark" of *D. uliginosa*, all obtained from Fiji. No rotenone could be detected in either the leaves or stems of *D. elliptica*, or in the leaves of *D. uliginosa*, by the color test for rotenone recently outlined.[7,8] A positive color test was obtained from the stems of *D. uliginosa* and from the sample

[1] Received July 24, 1933.
[2] This JOURNAL **23**: 36. 1933.
[3] Pharm. Arch. **5**: 145. 1902; **6**: 1. 1903.
[4] J. Agric. Research **17**: 177. 1919.
[5] J. Econ. Entom. **23**: 619. 1930.
[6] Agric. Jour. (Fiji Dept. Agric.) **5**: 34. 1932.
[7] Ind. Eng. Chem., Anal. Ed. **5**: 75. 1933.
[8] The rotenone color tests in this work were made on concentrated acetone extracts of the plant materials.

TABLE 1.—ROTENONE CONTENT OF VARIOUS MATERIALS

Sample Number	Plant Material		Source	Qualitative Color Test for Rotenone	Quantitative CCl_4 Extraction	
					Rotenone	Total Extract
1535	*Derris elliptica*	Stems	Fiji	Negative	—	—
		Leaves		Negative	—	—
1534	*D. uliginosa*	Stems	Fiji	Positive	about 0.1[a]	1.7
		Leaves		Negative	—	—
1309	*D. uliginosa*	"twigs and bark"	Fiji	Faintly positive	None[a]	1.5
1498	*Lonchocarpus nicou*	Large stems	Peru	Positive	about 0.1[b]	1.4
		Small stems and rachises		Negative	—	—
		Leaves		Negative	—	—
1522	*L. nicou*	Roots	Peru	Positive	8.3	17.8
		Stems		Positive	about 0.3[c]	3.2
		Leaves		Negative	—	—
1291	*L. nicou*	Leaves	Peru	Negative	—	—
1351	*L. nicou*	Fine roots	Peru	Positive	7.2	19.8
		Coarse roots		Positive	2.0	7.2
		Whole root			3.5	10.8
1352	*L. nicou*	Fine roots	Peru	Positive	6.9	17.0
		Bark of coarse roots		Positive	4.7	16.4
		Inner portion of coarse roots		Positive	1.2	5.0
		Whole root			2.9	9.3
618	*L. velutinus*	Bark of root	Unknown	Negative	—	—
		Inner portion of root		Negative	—	—
		Bark of stem		Negative	—	—
785	*L. velutinus*	Roots	Peru	Positive	1.9	12.2
1331	"Haiari" (*Lonchocarpus sp.*)	Stems	Unknown	Positive	1.0	4.8
1451	*Lonchocarpus sp.*	Roots	Paraguay	Positive	8.9	22.6
1452	"Cipo"; (*Lonchocarpus sp.*)	Roots	Brazil	Positive	1.2	9.1
1387	"Timbo"	Roots	Brazil	Positive	16.3	38.7

[a] 100-gram sample.
[b] For determination of rotenone a 1-kilogram sample was extracted at room temperature with ethylene dichloride, the extract evaporated to dryness in a vacuum and the rotenone crystallized from carbon tetrachloride. Total extract determined by carbon tetrachloride extraction of a 150-gram sample.
[c] 150-gram sample.

of "twigs and bark" of the same species. By the carbon tetrachloride extraction method[9] the stems gave about 0.1 per cent rotenone. No crystallizable quantity of rotenone could be obtained from the "twigs and bark."

Geoffroy[10] in 1895 found from 2 to 2.5 per cent rotenone in large stems of *L. nicou* from French Guiana and stated that the young stems contained only small quantities and the leaves only traces. Several samples of stems and leaves of authentic *L. nicou* from Peru have now been examined for rotenone. One sample of material was divided into large stems (those over 5 mm. diameter), small stems (including the rachises of the large, pinnately compound leaves) and the separated leaflets, here designated as leaves. The large stems of this sample contained about 0.1 per cent rotenone while the small stems and the leaves contained none. Another sample consisted of roots and stems, the latter ranging from 1 cm. to 2 cm. diameter, both taken from the same plant, which was two years and five months old and was growing at an altitude of 600 feet above sea level. The leaves received with this sample were from this plant and other plants within a radius of fifteen feet. The roots contained a large proportion of rotenone while the stem material contained only about 0.3 per cent. No rotenone could be detected in the leaves. A third specimen, consisting of leaves only, contained no rotenone.

The distribution of rotenone in the roots of *L. nicou* was also studied. Two samples of material were divided into fine (those less than about 5 mm. diameter) and coarse roots, and these portions were analyzed separately. As seen from the results given in the table the fine roots contained a much larger proportion of rotenone in both cases. Similar results were previously obtained with derris root.[11] One sample of the coarse cube roots was stripped of its bark (probably including other tissues immediately under the bark), and this was analyzed separately from the inner part of the root. The bark and the peripheral structures contained a definitely larger proportion of rotenone than the inner portion.

Two samples of *L. velutinus* were tested for rotenone. One of these contained no rotenone, while the other contained about 2 per cent. A sample of "Haiari" stem, a sample of roots said to be of a species of *Lonchocarpus* from Paraguay and a sample of "cipo" roots from Brazil all contained appreciable quantities of rotenone.

[9] Ind. Eng. Chem., Anal. Ed. **5**: 23. 1933.
[10] Ann. Inst. Colon. Marseille **2**: 1. 1895.
[11] This JOURNAL **23**: 36. 1933.

A sample of Brazilian "timbo" root contained about 16 per cent rotenone. This sample was submitted as *Paullinia pinnata*, but according to Killip and Smith[12] the term "timbo" is applied to *L. urucu* in the region from which this material came (Para). Unfortunately no leaf parts were submitted for botanical identification, and the root had undergone decomposition making impossible a microscopical comparison with an authentic sample of *P. pinnata*. A previous sample of "timbo" root from this same region contained about 5 per cent rotenone.[11]

CONCLUSIONS

The results obtained indicate that the stems and leaves of derris and cube are of no value as commercial sources of rotenone.

Fine cube roots contain a higher proportion of rotenone than the coarse roots. The outer portion of the root has a higher rotenone content than the inner part.

Roots of other species of *Lonchocarpus* should be further investigated as possible sources of rotenone.

[12] This Journal **20**: 74. 1930.

PALEONTOLOGY.—Salonia, *a new Ordovician brachiopod genus.*[1]

G. Arthur Cooper and Lawrence Whitcomb. (Communicated by John B. Reeside, Jr.)

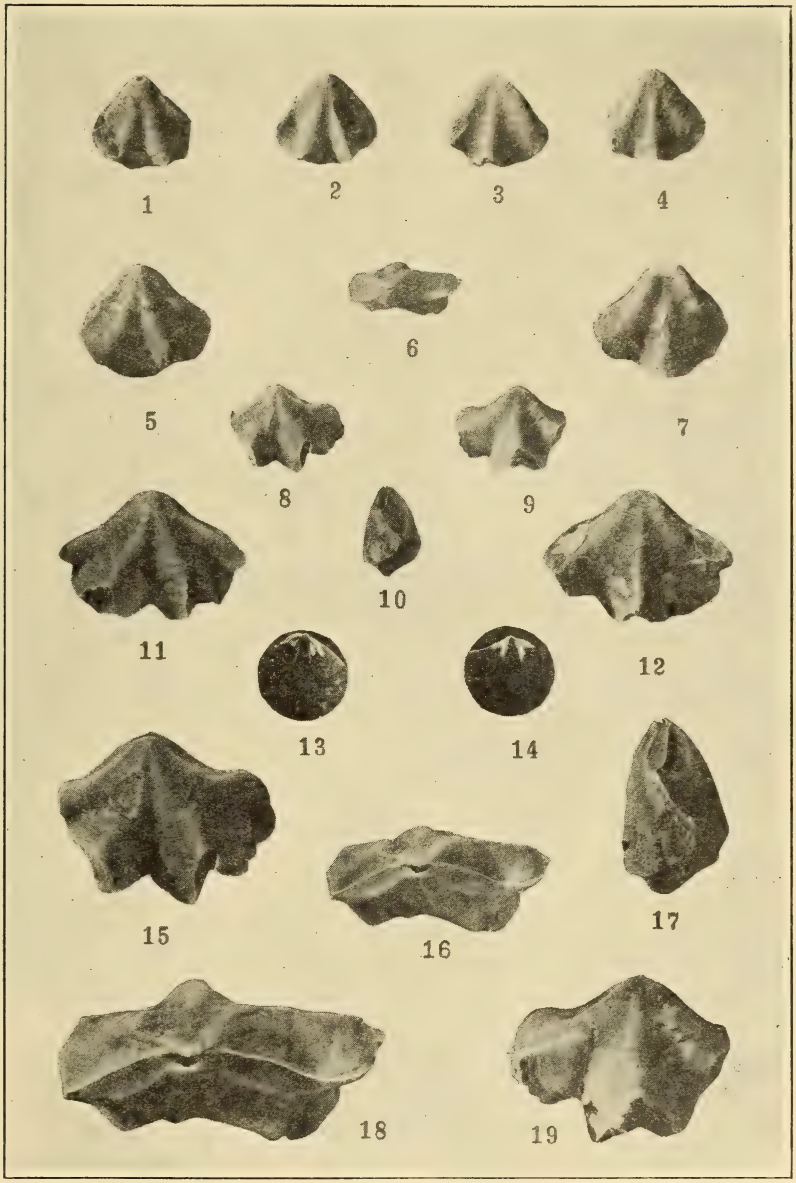
The genus herein described is characterized by a distinctive external appearance and is particularly interesting as the earliest known

[1] Published by permission of the Secretary of the Smithsonian Institution. Received May 25, 1933.

Figs. 1–19.—*Salonia magnaplicata* Cooper and Whitcomb, n. sp.

Figs. 2, 3.—Ventral and dorsal valves respectively of a small individual (paratype 85422 *e*) showing the triangular outline, ×2. Figs. 1, 4.—Same views as above of paratype 85422 *d*. Figure 1 shows the costella in the ventral sulcus, ×2. Figs. 5, 7.—Ventral and dorsal views respectively of a larger specimen (paratype 85422 *c*) retaining the triangular form but showing the beginning of lobation. Figure 7 illustrates well the sulcus on the dorsal valve a little anterior to the beak. This soon inverts to form the prominent fold, ×2. Figs. 11, 12.—Ventral and dorsal views respectively of a nearly full grown individual. In this specimen the fold and sulcus are more angular than the others. The costella of the sulcus shows plainly in figure 11. Patches of shell substance may be seen in figure 12, which indicate how thin the shell was. Paratype 85422 *b*, ×2. Figs. 6, 8, 9, 10.—Respectively posterior, ventral, dorsal and lateral views of the holotype 85422 *a*, ×1. Figs. 15, 19.—Respectively ventral and dorsal views of the holotype. ×2. Figs. 16, 17.—Posterior and lateral views respectively of the holotype, ×2. Fig. 18.—Posterior view of the holotype showing strongly incurved dorsal beak. ×3. Figs. 13, 14.—Posterior views of the dorsal interior showing the dental sockets and long brachial processes. These appear slender because they are seen from a ventral position. Compare figure 14 with text figure 22A. Figure 13 is of paratype 85422 *r*; figure 14 is of paratype 85422 *p*.

All of the specimens figured are from twelve feet above the base of the Trenton (Salona) formation, along the railroad track beside Fishing Creek, Salona, Clinton County, Pennsylvania.



Figs. 1–19.—*Salonia*: A new Ordovician brachiopod genus. For explanation see opposite page.

brachiopod having the internal features of the Pentameridae. A single specimen of this genus was discovered by Dr. Whitcomb while investigating problems of the Trenton strata at Salona, Clinton County, Pennsylvania. Subsequent to its discovery two additional visits to the brachiopod locality yielded material in sufficient quantity to allow the preparation of a detailed description of the genus. All of the specimens are from the Salona formation of lower Trenton age,[2] exposed

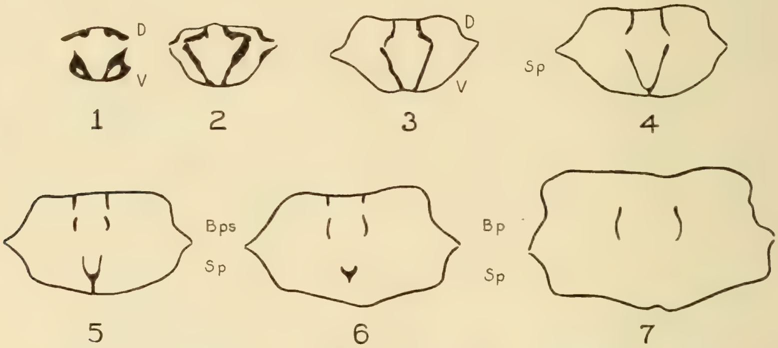


Fig. 20.—Serial sections of a half-grown individual showing the structure of the internal plates. ×9. Distances of the sections from the apex of the dorsal beak: 1 – 0.47 mm.; 2 – 0.61 mm.; 3 – 0.77 mm.; 4 – 1.04 mm.; 5 – 1.33 mm.; 6 – 1.54 mm.; 7 – 2.07 mm. In this specimen the tip of the ventral beak was located 0.25 mm. anterior to the tip of the dorsal beak. In section 1 therefore the structure shown is 0.22 mm. below the tip of the ventral beak. All sections *ca.* ×7. *V*—ventral valve, *D*—dorsal valve, *sp.*—spondylium. Fragment remaining after cutting is paratype 85422 *l*.

The key to the symbols in Figures 20, 21, 22, and 23 is as follows:

Ap —alar process
Bp —brachial process
Bps—septum supporting brachial process
D —dorsal valve
Ip —inner plate
Ms —median septum supporting spondylium
S —dental socket
Sp —spondylium
Spt —thickened rim of spondylium
V —ventral valve

along the railroad track beside Fishing Creek at Salona. The name of the genus has been derived from the formation name and its locality.

The particular bed yielding this unusual brachiopod is located twelve feet above the base of the Salona formation and seven feet below the base of the lowest bentonite bed in the formation. Since the bentonite beds have proved to be readily recognizable horizons[3] both measurements are given.

[2] Field, R. M. *The Middle Ordovician of Central and South Central Pennsylvania.* Amer. Jour. Sci. **28**: 420–421. 1919.
Whitcomb, L. *Correlation of Ordovician limestone at Salona, Clinton County, Pennsylvania.* Penn. Geol. Surv. Bull., G-5, 1932.

[3] Whitcomb, L. *Correlation by Ordovician bentonite.* Jour. Geol. **40**: 522–534. 1932.

The material and its preparation.—The material on which the generic and specific descriptions of *Salonia* are based consists of ten complete or nearly complete individuals and several fragmentary specimens and isolated valves. Dr. Whitcomb deposited all of the types in the United States National Museum (Cat. no. 85422*a–s*). Several paratypes are at Lehigh University. One specimen (85422*a*) has been selected as the holotype (see Figs. 15–19). The specimens are preserved in a dark limestone to which the shell adheres firmly. Consequently no specimen was obtained with the shell intact. All of the specimens therefore were much exfoliated when broken out of the matrix. Hard limestone usually makes difficult material to prepare for internal structures. The following methods were employed in the preparation of the material for determination of the internal characters.

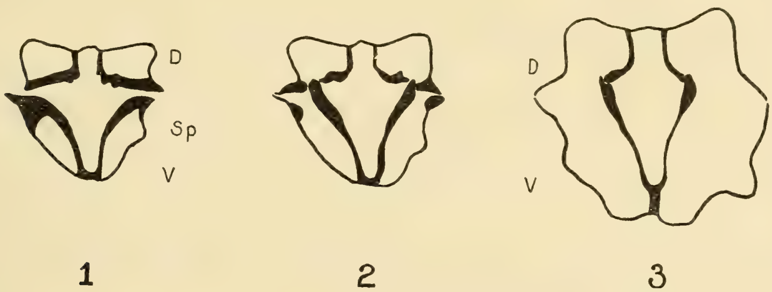


Fig. 21.—Serial sections through the posterior of a large specimen. In this specimen both beaks were on about the same level, the dorsal beak not overhanging the ventral delthyrium as usual. Distance of the sections from the tip of the beaks: 1 — 0.28 mm.; 2 — 0.50 mm.; 3 — 0.82 mm. *V*—ventral valve; *D*—dorsal valve. Fragment, paratype 85422 *m*.

As a first or preliminary method to determine the gross structure of the interior in a general way the beaks of one specimen were washed with dilute hydrochloric acid. This treatment revealed the internal septa at their junction with the inner surface of the valve. This method is of great use in the study of pentameroid brachiopods and has the advantage of not appreciably damaging the specimen. The method is therefore much preferable to cutting the beaks.

In order to determine the structure of the septal plates two fragmentary specimens preserving both beaks were sectioned and the structures sketched with the aid of a camera-lucida (see Figs. 20 and 21). To check the information thus obtained, the dorsal cardinal region and the septa were exposed by working the matrix away from the plates. This was accomplished by scraping away the matrix with

needles ground to a chisel edge. A lateral view of the interior was obtained by the same method (see Fig. 22 *A–C*).

Salonia Cooper and Whitcomb n.g.

Shell trilobate, pauciplicate, uniplicate; hinge narrow; interareas obsolete; fibrous, impunctate. Interior of ventral valve provided with a short spondylium. Dorsal interior with two long septa supporting curved, sabre-like brachial processes.

Genotype.—*Salonia magnaplicata* Cooper and Whitcomb n. sp.; Salona formation, Salona, Clinton County, Pennsylvania.

Salonia magnaplicata Cooper and Whitcomb n. sp.

Exterior.—Trilobate in outline, wider than long when adult; hinge narrow, equal to one-eighth to one-ninth the width of the shell. Lateral profile gently biconvex. Anterior commissure uniplicate. Beaks small, obtuse, forming an angle slightly more than ninety degrees. Surface pauciplicate, with three subangular to angular plicae on the dorsal valve and four on the ventral valve. The ornamentation consists of fine growth lines and heavier growth varices. Shell substance thin.

Ventral exterior.—Shell slightly convex posteriorly, deeply sulcate anteriorly. Sulcus subangular to angular; lingual extension elongate dorsally, subacute to acute. Sulcus occupied by a single, slender, median costella extending from near the beak to the anterior margin (Figs. 1, 11). The plications bounding the sulcus are low, subangular anteriorly, gently rounded posteriorly and extend as low elevations nearly to the beak. Lateral slopes deeply concave, bounded by prominent, acute beak ridges. Between the beak ridges and the antero-laterally sloping line of valve junction is a narrow concave area. The delthyrium is nearly as wide as the hinge and is uncovered.

Dorsal exterior.—Trilobate; two subangular folds curve gently antero-laterally from the beak to the lateral margin. In young specimens the folds extend antero-laterally with little or no curvature. Median fold subangular to angular anteriorly but becoming obsolete posteriorly at a point about one and one-half to two and one-half millimeters in front of the beak. In the umbonal region there is a shallow median concavity bounded by low lateral plications. There is thus a reversal of sulcus to fold during the growth of the shell (see below). The region between the posterior commissure and the lateral plications is concave. Beak strongly curved over the ventral delthyrium, apsacline. Notothyrium narrow.

Ventral interior.—Spondylium short, sessile posteriorly, elevated at the front on a short, low septum. The total length of the structure as revealed on the exterior of the holotype is a little less than two millimeters. On each side of the spondylium in the holotype there are low calcareous ridges, disposed radially, which undoubtedly represent the seat of attachment of muscles from the ovarian bodies (see Figs. 20, 21, 22).

Dorsal interior.—On the exterior of the dorsal valve, when the shell is exfoliated or dissolved away, may be seen the bases of two septa which diverge gradually anteriorly. Internally these septa unite with long brachial processes. Seen from the inside the dorsal structures are plainly divisible into several distinct plates. Next to the thickened margin of the valve is a flat-

tish, triangular plate, the anterior margin of which bounds the dental socket. The latter is a moderately deep indentation between the thickened side of the valve and the thickened or ventral margin of the brachial process. The

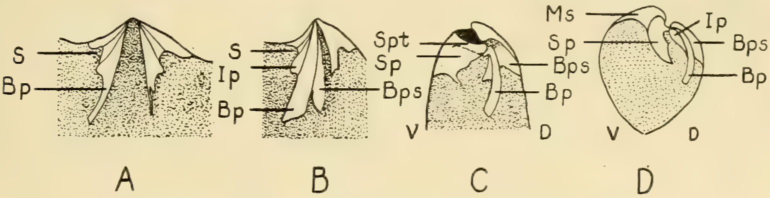


Fig. 22.—Views of the interior of the dorsal valve.

A. Camera-lucida sketch of the interior of the dorsal valve drawn from the specimen (paratype 85422 *p*) figured on figure 14. Sketch, *ca.* ×7.

B. Same turned to the left to show position of the septal plate supporting the brachial process. *ca.* ×7.

C. Internal structures seen in profile. Camera-lucida sketch drawn from paratype (85422 *q*). *ca.* ×4.

D. Lateral view of the internal septa of *Gypidula* (U.S.N.M. 88826 *a*) introduced for comparison with *Salonia*. *ca.* ×1.

latter is long, curved and blade-like at its free end. Its base can be traced posteriorly between the inner plate and the septal supporting plate nearly to the beak and is united with the supporting septum dorsally and the inner plate ventrally. The supporting septum of the brachial process tapers to disappearance at its front end some distance behind the blunt end of the brachial process. No cardinal process was observed; the diductor muscles were evidently attached to the floor of the valve under the beak. The seat of attachment of the adductor muscles was probably the floor of the valve between the septal plates. Owing to the tenuity of the shell no muscle marks were observed (see Figs. 20, 21, 22).

Measurements

Paratype	Width of hinge mm.	Length mm.	Width mm.	Thickness mm.	Length ventral septum mm.	Length dorsal septa mm.
85422 *e*........	—	6.0	6.5	1.5	1.0	1.25
85422 *d*........	1.0	6.0	6.5	2.0	1.5	1.75
85422 *c*........	1.25	7.5	9.0	3.0	1.75	—
85422 *b*........	1.5	8.0	12.5	5.0	2.0	2.5
Holotype						
85422 *a*........	2.0	12.0	18.0	6.0	1.5	3.0

Growth.—As shown by well preserved growth-lines on paratype (85422 *c*) *Salonia* in its earliest stages (protoconch to a little less than one millimeter) was a circular or nearly circular shell with a sulcate dorsal valve and a ventral valve having a fairly prominent fold. The dorsal valve was sulcate in valves having a length of one and one-half to two and one-half millimeters. In about the center of the sulcus of the dorsal valve was a faint costella corresponding to the fold which develops in later life. After a length of one and one-half to two and one-half millimeters is reached the dorsal sulcus inverts to form a prominent fold and lobation is initiated. A shell six millimeters in length (Figs. 1–4) is distinctly triangular but after this length has been reached the shell widens notably to produce the adult form.

Discussion.—At first glance *Salonia* suggests certain Mesozoic brachiopods but the interior is clearly that of a more ancient shell. The decided

lobate exterior and subangular folds are unusual features in such an ancient brachiopod. The complete absence of a ventral interarea (cardinal area) is an advanced character seen in later stocks of the Pentameracea. The peculiar manner in which the dorsal beak overhangs the delthyrium is unusual. The ensemble of external characters alone would warrant the erection of a

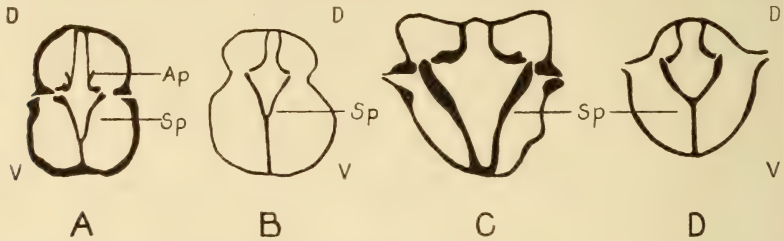


Fig. 23.—Sections of pentameroids for comparison with *Salonia*. All of the sections were cut at or near the plane of articulation of the valves.

A. *Parastrophinella reversa* (Billings)—This section shows the alar processes (*Ap*) which are characteristic of the Camerellidae but unknown in other Pentameracea. Such processes are wanting in *Salonia*. After Schuchert and Cooper, ×1.5.

B. *Pentamerus* aff. *P. oblongus* (Sowerby)—This is a characteristic member of the non-galeate Pentameridae showing the septa of the dorsal valve and the prominent median septum supporting the spondylium (*Sp*). After Schuchert and Cooper, ×1.3.

C. *Salonia magnaplicata* Cooper and Whitcomb—Note the sessile spondylium in the ventral valve. Absence of alate processes differentiates this genus from the Camerellidae. Resemblances of the dorsal septa to those of *Pentamerus* and *Gypidula* are obvious. This section was cut at about the position on C of figure 22 where the line from *Spt* would cut across the shell if continued. *ca.* ×10.

D. *Gypidula* sp. (U.S.N.M. 88826 *b*)—Section cut near the plane of articulation. *ca.* ×2.

new generic name for this shell, but combined with its pentameroid interior this brachiopod proves to be quite novel.

The spondylium is unusual for its brevity and primitive character. In the holotype the spondylium and its septum are unusually short, in fact shorter than in some of the smaller shells. Unlike the more advanced spondylium of the Gypidulinae and Pentamerinae, that of *Salonia* is sessile or rests on the floor of the valve posteriorly (see Figs. 20, 21, 23). In other words at the back end of the valve the dental plates descend ventrally to the floor of the valve (see Fig. 20), but anteriorly they are elevated to join a low median septum. This appears to be an early character seen commonly in the Syntrophiidae, Clarkellidae and Camerellidae, all probably improperly classified in the Pentameracea. The spondylium of the Gypidulinae and Pentamerinae is rarely if ever sessile (see Fig. 23).

The structure of the dorsal valve is closest to that of the Gypidulinae. The sockets are located as in *Gypidula* (see Figs. 22*C*, 22*D*, 23) and the arrangement of plates described by Leidhold[4] is clearly visible in *Salonia*. The inner plate forms a sort of roof over the umbonal chambers made by the

[4] Leidhold, Cl. Abhandl. preuss. geol. Landesanst., n. ser., 109: 51–53. 1928.

septa and the side of the valve. The sockets for the reception of the teeth are a notch in the inner plate. The brachial process is fairly long, thin and blade-like. Its cross-section is crescentic, the concavity of the crescent facing the inside of the valve. The extremity of the process is blunt. The brachial process protrudes freely at its front end but posteriorly it is intimately united with the other plates. Below or dorsally from the brachial process are the septal plates which support the whole structure. It will thus be seen that the cardinalia of *Salonia* are like those of the Gypidulinae or Pentamerinae but differ in details (see Figs. 22 and 23).

Relationships.—Judging by the stratigraphic horizon from which *Salonia* comes one would expect this shell to be closely related to the Camerellidae. Comparison with camerellids (see Fig. 23*A*), however, suggests that close relationship, at least, is not evident. The Camerellidae, as seen in *Camerella* and *Anastrophia,* are characterized by a peculiar type of cardinalis that is more orthoid than pentameroid. There may be a cruralium (*Camerella*) or discrete septal plates (*Anastrophia, Parastrophinella*) which support wing-like brachial processes. The sockets are defined by fulcral plates which are wanting in *Salonia* and the Pentameridae. The cardinalia of *Salonia* and the Camerellidae are thus quite distinct although the spondylium of the two has considerable resemblance in the common character of sessility at the posterior.

The closest relationships of *Salonia* that we could find are with the Gypidulinae. Here the position of the dental sockets and the arrangement of the plates are essentially the same (see Fig. 22*D*). Moreover the brachial processes of the two are broad blades and in this respect different from the Pentamerinae which have very slender processes. So far as present knowledge of *Salonia* goes, its relationships are closest to the Gypidulinae of the Pentameridae. It is an anomaly that the earliest known shell that can be related to the Gypidulinae or Pentamerinae is of such an advanced character. It is apparent that the true course of brachiopod evolution is still far from being understood.

PALEOBOTANY.—*A* Knowltonella *from the Black Hills Cretaceous.*[1]

EDWARD W. BERRY, Johns Hopkins University.

The genus *Knowltonella* was proposed by the present writer[2] for rather abundant remains from the Patapsco formation of Maryland. These were tentatively referred to the fern family Matoniaceae, although Seward[3] regards this comparison as "by no means convincing." So far as I know the genus has not been found outside of North America, although it is incidentally mentioned by Kryshtofovich[4] as

[1] Received June 15, 1933.
[2] BERRY E. W. Md. Geol. Survey Lower Cretaceous, p. 233, *pls. 25–27.* 1911.
[3] SEWARD, A. C. *Plant life through the Ages,* p. 394. 1931.
[4] KRYSHTOFOVICH, A. The Pacific Russian Scientific Investigations, p. 61. 1926.

present in the upper Nikan series of Ussuriland, associated with *Marchantites*, *Weichselia*, *Zamiopsis*, and *Pandanophyllum* (a supposed Angiosperm), at a horizon apparently well up in the Lower Cretaceous.

For some years now I have been endeavoring to harmonize the fossil plants with the supposed stratigraphy and areal mapping of the Cretaceous of the Black Hills in South Dakota and Wyoming. Much of the material studied is new and was collected by Henry E. Lee of

Fig. 1.—*Knowltonella* from the Black Hills Cretaceous.

Rapid City, but I have also had the free use of the older collections in the U. S. National Museum. Much of the material recorded from the Black Hills Cretaceous is very poorly preserved in mostly small fragments in a prevailingly coarse matrix which leaves much to be desired in attempting critical determinations.

For this reason it seems worth placing on record a new and biologically interesting addition to the flora of the region—a plant whose identity can not possibly be mistaken. Figure 1 shows a specimen collected by T. W. Stanton and W. W. Rubey, August 17, 1924 about 9 miles northwest of Aladdin, Wyoming, from the bank of Pine Creek and near the south line of Sec. 13, T. 55 N., R. 62 W. (U. S. Geol. Survey Loc. No. 7774).

This is identical with *Knowltonella maxoni* the type and only known species of the genus. There is no necessity of a detailed description of this interesting specimen as it adds nothing to what is already known and printed concerning the species.

There is considerable resemblance to the Patuxent species *Scleropteris elliptica* Fontaine,[5] but there is slight occasion for confusing the two. The latter lacks the extreme variation of *Knowltonella*, all of the pinnules being uniform in size and shape, less ascending, rather uniformly narrowed at the base, and in no part of the frond exhibiting the extreme decurrence, asymmetry and elongated linear wings so frequent in *Knowltonella*.

Fontaine described[6] two species of *Scleropteris* from the supposed Lakota formation on the south fork of Hay Creek, Wyoming. Neither of these is anything like the species under consideration and I would hesitate to consider either a *Scleropteris* or to suggest their proper generic reference, since they are so very incomplete.

Scleropteris Saporta, 1873 is one of a group of generic names including *Pachypteris* Brongniart, 1828, *Thinnfeldia* Ettingshausen, 1852, and *Dichopteris* Zigno, 1856, which have occasioned the greatest differences of opinion and confusion among students of Mesozoic floras. Without being strictly identical these pseudogenera all overlap and no one has as yet been able to prove whether they belong to the ferns or cycads or may not even be surviving pteridosperms allied to the Paleozoic odontopterids, as Seward has suggested. Any discussion of this question would add little or nothing to their present status and is not germane to the present note.

Knowltonella has every appearance of representing a true fern, but one can never be sure of these Mesozoic fern-like fronds until the epidermal structure or fruiting characters are known. Many years ago (1909) I collected splendid material of the type species at Widewater, Virginia, which gave every indication of having the epidermal features preserved, but this was accidentally destroyed, and I have never been able to revisit the locality.

[5] Berry, E. W. Md. Geol. Surv. Lower Cretaceous, p. 300, *pl. 39, figs. 1, 2.* 1911.
[6] Fontaine, W. M. in Ward, L. F. 19th Ann. Rept. U. S. Geol. Survey, Pt. 2: 662, 663, *pl. 162, figs. 2–5.* 1899.

PALEOBOTANY.—*The cuticle of an Eocene* Combretum.[1]

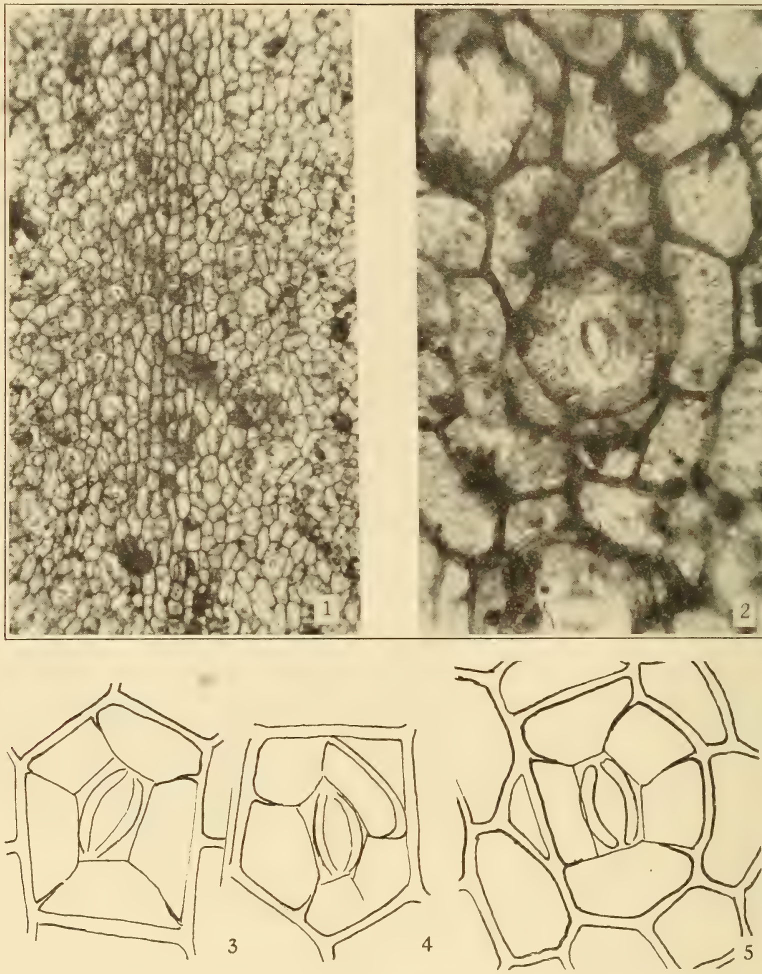
Edward W. Berry, Johns Hopkins University.

In a collection sent me several years ago by Mr. Watson A. Monroe, there is a single basal half of a leaf which I have identified as representing the common Eocene species *Combretum petraflumensis*

[1] Received June 20, 1933.

Berry,[2] although the specimen is too incomplete to be perfectly certain.

This species is very common in the Texas region in the Yegua and Fayette formations but has not heretofore been found east of the



Figs. 1–5.—1. Cuticle of *Combretum petraflumensis.* ×60; 2. Detail of stoma. ×320; 3–5. Sketches showing structure of the stoma and accessory cells.

Mississippi River, that is, in what has been called the Eastern Gulf Region. The present specimen comes from the Yegua formation near Jackson, Mississippi.

[2] Berry, E. W. U. S. Geol. Survey Prof. Paper **92:** 85, *pl. 45, figs. 1–4; pl. 58, figs. 2–4; pl. 59, figs. 1–5.* 1924.

It shows what appears to be a spot fungus, but I was unable to get any microscopic preparations of these spots. The material had dried out considerably before it came into my hands but I succeeded in making several cuticular preparations and these show the gross outlines of epidermal cells and pores with fidelity.

The stoma are certainly largely, and perhaps wholly, confined to the lower surface of the leaf where they are rather evenly distributed and in the preparations studied are 0.109 to 0.116 millimeters apart and without any particular orientation. The cuticular cell walls are relatively thick, and straight oı slightly curved (not undulating). Their outlines are polygonal and they show some variation in size. In general they tend to be isodiametric except over the veins where their long diameters are parallel to the venation as shown across the middle of the microphotograph in Fig. 1 which is enlarged 60 diameters. The apparent greater thickness of the walls over the veins is due entirely to the better focus on this part of the specimen. It is difficult to be sure regarding the stoma. Usually these are surrounded by a rather symmetrical pentagonal thick walled border about 56 microns in diameter, in the center of which are the open and familiar sausage-shaped guard cells. These appear to be sunken below the surface, i.e. at the bottom of a shallow pit. Figure 2 shows their appearance with a magnification of 320 diameters. In this figure the central pore is in focus and nearby pores can be seen less clearly slightly out of focus. Although there has been some decay possibly due to the invasion of the mesophyll by fungal hyphae, and the details are not clear, I am reproducing sketches of three of the stoma (Figs. 3, 4, and 5). These appear to show 5 accessory cells around the opening. The peripheral dividing walls are frequently thick but appear to taper inward and the inner part of these divisions as well as the inner margins show no thickening and no change in adjustment of focus shows any such thickening, i.e. there is no visible evidence that the inner walls are oblique to the outer walls. Sometimes the divisions lie at the angles of the periphery and oftener they do not.

Several rather widely spaced wall knots that are above the general surface level might be interpreted as papillae, but there are no traces of trichomes. In both Fig. 1 and Fig. 2 there may be seen rather straight strands continuing across and behind several cells. These may be mycelial hyphae or they might be traces of sclerenchyma fibres which ended freely in the mesophyll during life. The diameters of the epidermal cells range approximately from 30 to 70 microns.

I have not compared these fossil preparations with those from

existing leaves as the subject is so vast in its details and so little is known in a systematic way of Angiosperm cuticular structures. According to the brief summary of leaf anatomy of *Combretum* that is given by Solereder, *Combretum* may have the epidermal cells with undulate or straight walls, there may be papillae on the under surface and sclerenchyma fibres in the mesophyll. The walls are said to be not much thickened and special subsidiary cells are absent.

The fossil features agree partly with this statement and partly not. It is possible that what I have considered as 5 accessory cells may be ordinary epidermal cells in which the inner margins were not especially thickened and thus the resemblance to various gymnosperm stomata may be illusory.

ZOOLOGY.—*On some nematodes of the superfamily Rhabditoidea and their status as parasites of reptiles and amphibians.*[1] B. G. CHITWOOD, Bureau of Animal Industry. (Communicated by G. STEINER.)

In the course of examinations of reptiles and amphibians, the writer has found four nematodes which do not belong in any of the recognized groups of vertebrate parasites, but appear definitely to be most closely related to those groups generally referred to as "free-living."

In addition to the descriptions of these four species, a new genus, *Goodeyus*, is proposed to contain *Cylindrogaster ulmi* Goodey. A new family, Cylindrogasteridae, is also proposed to contain the genera *Cylindrogaster* Goodey, *Goodeyus*, n. g., *Myctolaimus* Cobb, and *Longibucca* n. g., since these genera differ from those of the families Rhabditidae and Diplogasteridae in characters which appear to warrant uniting them in a separate family.

Family ANGIOSTOMATIDAE R. Blanchard, 1895, emend. Lane, 1923

Synonym.—*Angiostomidae* R. Blanchard, 1895.

Family diagnosis.—Rhabditoidea: Oral opening surrounded by dorsal and two subventral indistinct lips (without lips, according to Dujardin (1845) and Schneider (1866)). Internodorsal, internolateral, and internoventral cephalic papillae rudimentary; dorsodorsal, ventroventral, and ventrolateral papillae small; laterodorsal and lateroventral papillae large.[2] Buccal capsule short and wide. Esophagus consists of a corpus, or anterior part, provided

[1] Received May 29, 1933.

[2] The designations for the various cephalic papillae used in this paper were proposed by Chitwood, Journ. Parasitol. **19**: 167. 1932.

with a rudimentary swelling, an indistinct isthmus, and a posterior, glandular pseudobulb.[3] *Male:* Caudal alae well developed, incompletely united posteriorly to form a rhabditoid bursa, supported by papillae; tail extending a short distance beyond bursa. Two spicules; gubernaculum present. *Female:* Amphidelphic, ovaries reflexed; eggs numerous.

Type genus.—Angiostoma Dujardin, 1845.

The family Angiostomatidae may be separated from the family Rhabditidae on the basis of the labial organs, there being three lips in the Angiostomatidae while there are either three bilobed lips or six simple lips in the Rhabditidae, and on the basis of the esophagus which terminates in a pseudobulb in the Angiostomatidae and a bulb in the Rhabditidae. It differs from the Diplogasteridae in the character of the esophagus, a distinct corporeal swelling being absent in the Angiostomatidae and present in the Diplogasteridae, and in the presence of well developed caudal alae which are united to form a rhabditoid bursa in the members of the Angiostomatidae while caudal alae are narrow or absent in the Diplogasteridae.

ANGIOSTOMA Dujardin, 1845

Generic diagnosis.—Angiostomatidae: Amphids represented by minute pores situated slightly dorsal and posterior to ventrolateral papillae. Buccal capsule thick-walled, more or less infundibuliform. Esophagus consists of a corpus or anterior part provided with a rudimentary swelling, an isthmus, and a reduced glandular pseudobulb. *Male:* Testis single; caudal alae well developed, almost united posteriorly to form a rhabditoid bursa; tail extending slightly posterior to bursa. Bursal papillae large; paired subventral postanal papillae present, at least in *A. plethodontis.* Two spicules, equal, indistinctly cephalated proximally, curved distally; gubernaculum present. *Female:* Vulva near middle of body; vagina short, transverse; uteri divergent; ovaries reflexed.

Type species.—Angiostoma limacis Dujardin, 1845.

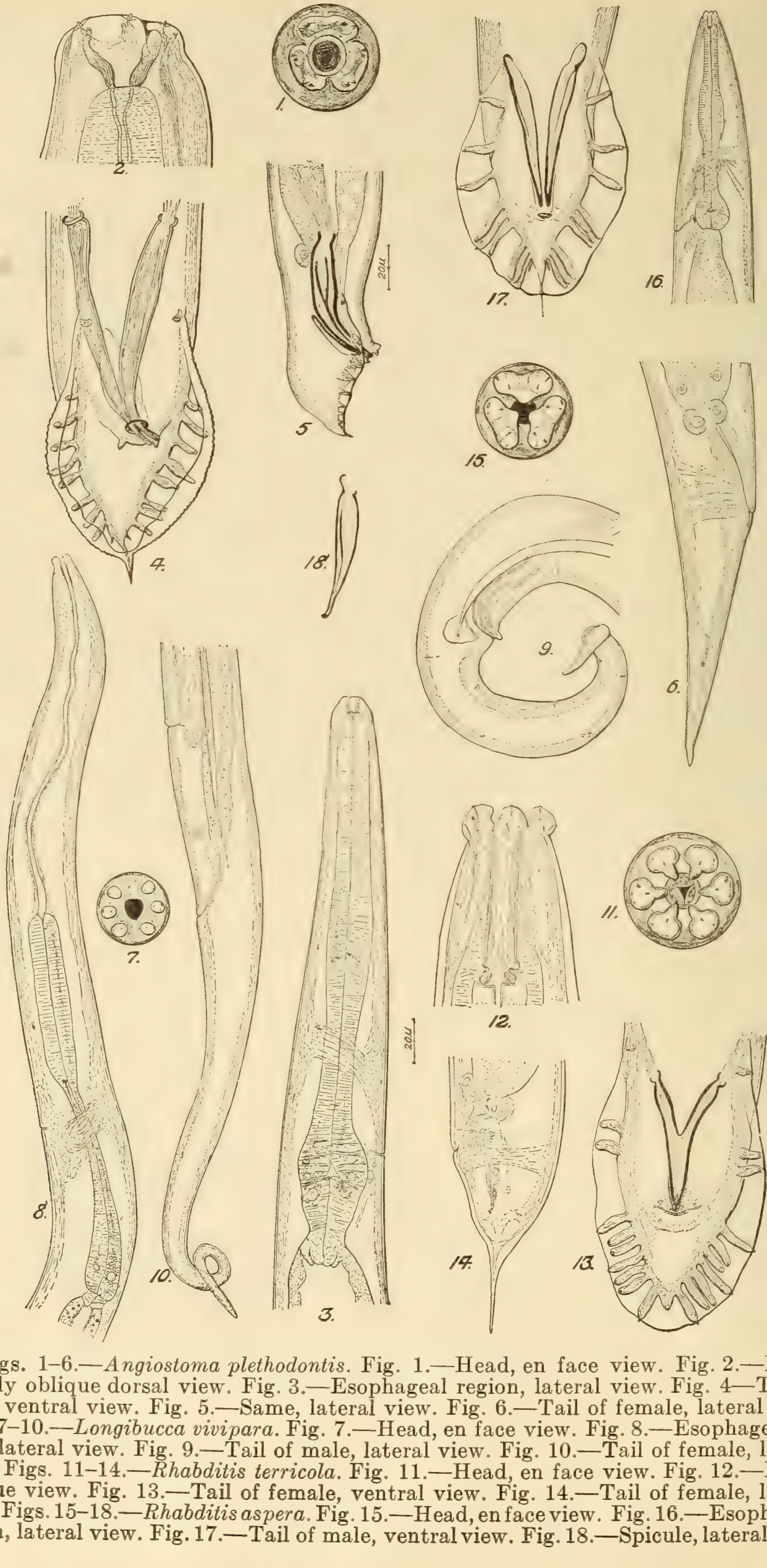
Angiostoma plethodontis n. sp.

(Figs. 1–6.)

Specific description.—Angiostoma: Buccal cavity 8 to 8.5μ deep, thick-walled, more or less infundibuliform.

Male 2 mm. long by 60μ wide. Esophagus consists of an anterior part or corpus, 100μ long, indistinctly set off posteriorly, an isthmus 56μ long by 9μ wide, and a posterior glandular pseudobulb 45μ long by 25μ wide. Anus 34μ from posterior end of body. Testis single, reflexed. Caudal alae well developed, almost united posteriorly to form a rhabditoid bursa. Tail extending beyond bursa as a minute posterior projection. Caudal papillae consisting of nine pairs of bursal papillae; two pairs preanal and seven pairs postanal, the fifth and eighth pairs terminating on dorsal surface of bursa while other pairs terminate on ventral surface (Figs. 4 and 5). Phasmids or lateral tail papillae present. Preanal organ immediately anterior to anus, possibly bearing sensory endings. One pair of conical, postanal, subventral

[3] The term bulb in connection with the description of the esophagus is reserved for the posterior swelling in which valves are present, and pseudobulb for this structure in which valves are absent.



Figs. 1–6.—*Angiostoma plethodontis.* Fig. 1.—Head, en face view. Fig. 2.—Head, slightly oblique dorsal view. Fig. 3.—Esophageal region, lateral view. Fig. 4—Tail of male, ventral view. Fig. 5.—Same, lateral view. Fig. 6.—Tail of female, lateral view. Figs. 7–10.—*Longibucca vivipara.* Fig. 7.—Head, en face view. Fig. 8.—Esophageal region, lateral view. Fig. 9.—Tail of male, lateral view. Fig. 10.—Tail of female, lateral view. Figs. 11–14.—*Rhabditis terricola.* Fig. 11.—Head, en face view. Fig. 12.—Head, oblique view. Fig. 13.—Tail of female, ventral view. Fig. 14.—Tail of female, lateral view. Figs. 15–18.—*Rhabditis aspera.* Fig. 15.—Head, en face view. Fig. 16.—Esophageal region, lateral view. Fig. 17.—Tail of male, ventral view. Fig. 18.—Spicule, lateral view.

papillae near anus. Spicules equal, 60μ long, cephalated proximally, curved distally. Gubernaculum 25μ long.

Female 2.3 to 2.5 mm. long by 75 to 88μ wide. Esophagus consisting of an anterior part or corpus 110 to 114μ long with a minimum diameter of 12μ and a maximum diameter of 16 to 17μ, an isthmus 60 to 62μ long by 10 to 12μ wide, and a pseudobulb 50 to 52μ long by 28 to 30μ wide. Nerve ring 147μ and excretory pore 207μ from anterior end of body, respectively. Intestine narrow in region of esophago-intestinal valve, slightly enlarged in cardiac region. Anus 104 to 110μ from posterior end of body. Rectal glands well developed. Tail attenuated. Vulva 920μ to 1 mm. from anterior end of body (40 per cent of length of body from anterior end); vagina short, transverse; uteri divergent; ovaries reflexed. Eggs 50 to 52μ long by 26 to 28μ wide, numerous, showing a linear arrangement in uterus, apparently in one-cell stage at time of deposition.

Host.—*Plethodon cinereus.*

Location.—Intestine.

Distribution.—Black Pond, Virginia, U. S. A.

Type specimens.—U. S. National Museum, Helm. Coll. No. 31605; paratypes No. 33004.

The genus *Angiostoma* originally contained two species, *A. limacis* and *A. entomelas*, of which the former was subsequently designated type. Most of the earlier species of the genus *Rhabdias* Stiles and Hassall, 1905, have at some time been placed in the genus *Angiostoma*, but the differences between these two genera are so manifest as to make discussion unnecessary. *Angiostoma entomelas* has recently been removed from the genus *Rhabdias* by Travassos (1930) and made the type of his new genus *Entomelas*. There remain at the present time only two species in the genus in addition to the type, namely, *Angiostoma cylindricum* (Leidy, 1849) Diesing, 1851, and *Angiostoma helicis* Conte and Bonnet, 1904. Neither of these species, however, can be considered as a member of the genus *Angiostoma*. Leidy in his description of *Ascaris cylindrica* (=*Angiostoma cylindricum*) states definitely that in *A. cylindricum* there is a valvulated bulb at the base of the esophagus. Furthermore, the body proportions, as given by Leidy for this species, do not approach those of either *A. limacis* or *A. plethodontis*. From Leidy's description and from observations made by the writer on material in his personal collections from snails and slugs (to be published later), it appears that *A. cylindricum* belongs to the genus *Cosmocercoides* Wilkie, 1930. *Angiostoma helicis* appears from the character of the spicules to be also a member of the Cosmocercidae, but this species can not be properly allocated generically without further information.

There are discrepancies between the descriptions of *Angiostoma limacis* by Dujardin (1845), and of *Leptodera angiostoma* Schneider (1866) (=*A. limacis* Dujardin, 1845, renamed) by Schneider, concerning the character of the spicules and the male tail. The character of the caudal alae as described by Schneider for *L. angiostoma* approaches that of *A. plethodontis* more closely than it does that of *A. limacis*, but the spicules of *L. angiostoma* are

reported as leaf-like, while the spicules of *A. limacis* and *A. plethodontis* are arcuate. Ordinarily it would seem reasonable to consider *L. angiostoma* Schneider as a species of *Angiostoma* separate from *A. limacis* Duj., but until additional information is available this seems inadvisable, especially since Schneider himself considered *Leptodera angiostoma* the same as *Angiostoma limacis.*

CYLINDROGASTERIDAE, new family

Family diagnosis.—Rhabditoidea: Oral opening surrounded by six lips, each bearing a papilla of the internal circle (internodorsal, internolateral, and internoventral papillae); and an external circle of 6 or 10 papillae; papillae of external circle not mentioned in some instances. Amphids situated on lateral lips. Buccal cavity unusually long. Esophagus consisting of a cylindrical corpus, an isthmus, and a glandular pseudobulb. *Male:* Testis single; caudal alae present or absent; spicules equal; gubernaculum present. *Female:* Amphidelphic or prodelphic.

Type genus.—Cylindrogaster Goodey, 1927.

This family differs from the Diplogasteridae both in the form of the buccal cavity, which is longer in the Cylindrogasteridae than in the Diplogasteridae, and in the absence of the corporeal swelling in the Cylindrogasteridae, this structure being present in the Diplogasteridae. The members of the family Rhabditidae differ from the members of the family Cylindrogasteridae in the same manner as do those of the Diplogasteridae, with the additional difference of the absence of the valves in the posterior bulbous enlargement of the esophagus of the Cylindrogasteridae.

The writer includes in this family the genera *Cylindrogaster* Goodey, 1924, type *C. longistoma* (Stefanski, 1922); *Goodeyus* n. g., type *G. ulmi* (Goodey, 1930); *Myctolaimus* Cobb, 1920, type *M. pellucidus* Cobb, 1920; and *Longibucca* n. g., type *L. vivipara*, n. sp. For these genera the following diagnoses are formulated.

Key to the Genera of the Cylindrogasteridae

1. Male with caudal alae or bursa .... 2.
   Male without caudal alae or bursa .... 3.
2. Caudal alae narrow (as in *Rhabditella*); female amphidelphic .... *Cylindrogaster.*
   Caudal alae wide, forming a rhabditoid bursa; female monodelphic, prodelphic .... *Goodeyus.*
3. Lips well developed; female amphidelphic .... *Myctolaimus.*
   Lips indistinct; female monodelphic, prodelphic .... *Longibucca.*

Cylindrogaster Goodey, 1927

Generic diagnosis.—Cylindrogasteridae: Oral opening surrounded by six lips, each bearing a papilla of the internal circle (internodorsal, internolateral and internoventral papillae). Buccal cavity elongate, tubular. Esophagus consisting of an anterior, cylindrical corpus, an isthmus and a posterior, glandular pseudobulb. *Male:* Caudal alae narrow, not united posteriorly; tail long, filiform; extending beyond caudal alae. Caudal papil-

lae distributed as in the leptoderan group of rhabditids.[4] Spicules equal, cephalated, rather arcuate; gubernaculum present. *Female:* Amphidelphic; ovaries reflexed.

Type species.—Cylindrogaster longistoma (Stefanski, 1922) Stefanski, 1928. (*Synonyms.—Rhabditis longistoma* Stefanski, 1922; *Cylindrogaster coprophaga* Goodey, 1927.)

Other species.—Cylindrogaster macrolaima (Schneider, 1866) new comb. (*Synonyms.—Leptodera macrolaima* Schneider, 1866; *Rhabditis macrolaima* (Schneider, 1866) Oerley, 1886.)

The genus *Cylindrogaster* Goodey, 1927, was proposed to include *C. coprophaga* Goodey, 1927, but the type species was shown by Stefanski (1927) to be a synonym of *Rhabditis longistoma* Stefanski, 1922.

Leptodera macrolaima Schneider, 1866, was apparently overlooked by Stefanski (1922 and 1927) and by Goodey (1927 and 1930), since it bears a very close resemblance to *Cylindrogaster longistoma* and there appears to be some doubt whether the two species can be retained. *Cylindrogaster longistoma* differs from *C. macrolaima* (= *Leptodera macrolaima*) in that the isthmus of the esophagus is longer in the former species and there is one more pair of bursal papillae than in the latter. Whether or not these differences are attributable to more detailed descriptions of the more recently described species than of the earlier described species, can not be settled at this time.

Goodeyus new genus

Generic diagnosis.—Cylindrogasteridae: Oral opening surrounded by six lips each bearing a papilla of the internal circle (internodorsal, internolateral and internoventral papillae). Buccal cavity elongate, tubular. Esophagus consisting of an anterior cylindrical corpus, an isthmus, and a posterior pseudobulb. *Male:* Caudal alae united posteriorly to form a rhabditoid bursa; tail not extending beyond bursa; caudal papillae arranged as in the peloderan group of rhabditids. Spicules equal, acicular, slightly cephalated; gubernaculum present. Testis single, reflexed. *Female:* Prodelphic; ovary reflexed.

Type species.—Goodeyus ulmi (Goodey, 1930).

This genus is dedicated to Dr. T. Goodey.

Myctolaimus Cobb, 1920

Generic diagnosis.—Cylindrogasteridae: Oral opening surrounded by six relatively large lips, each bearing a papilla (? of the internal circle). Buccal cavity elongate, tubular. Esophagus consisting of an anterior cylindrical corpus, an isthmus and a pseudobulb. *Male:* Caudal alae absent; convex-conoid in anterior half, cylindrical and tapering to an acute point in posterior half. Caudal papillae consisting of 2 pairs of preanal, 1 pair of adanal,

[4] The terms "leptoderan" and "peloderan" are used in somewhat the same sense as Schneider (1866) used the genera *Leptodera* and *Pelodera*. Those rhabditids with relatively long tails extending some distance beyond the caudal alae, i.e., *Rhabditoides coprophaga* Goodey, 1929, and *Rhabditella leptura* Cobb, 1929, are referred to as the "leptoderan group of rhabditids," while those rhabditids with relatively short tails which are either entirely surrounded by the caudal alae, i.e., *Rhabditis terricola*, are referred to as the "peloderan group of rhabditids."

and 6 pairs of postanal papillae. Spicules linear, tapering and blunt; gubernaculum present. *Female:* Amphidelphic; ovaries reflexed.

Type species.—Myctolaimus pellucidus Cobb, 1920.

Dr. Steiner kindly called my attention to this genus.

Longibucca new genus

Generic diagnosis.—Cylindrogasteridae: Oral opening surrounded by six indistinct lips each bearing a papilla, the internodorsal, internolateral and internoventral papillae; external circle of papillae represented by laterodorsal, ventrolateral and lateroventral papillae. Amphids situated at base of lateral lips; amphidial opening round, minute. Buccal cavity nearly equal in length to esophagus proper, consisting of a short, cylindrical, thick-walled, anterior part indistinctly separated from posterior, delicate, tubular part. Posterior part of buccal cavity enclosed in fibrous tissue. Esophagus consisting of an anterior, cylindrical corpus indistinctly set off posteriorly, a narrow delicate isthmus, and a posterior, piriform pseudobulb. *Male:* Testis single, reflexed, caudal alae absent; tail attenuated; caudal papillae arranged as in the leptoderan group of rhabditids and in the diplogasterids. Two spicules, short, equal, sharply curved, alate; gubernaculum present. *Female:* Vulva in posterior part of body, near anus; prodelphic, ovary reflexed.

Type species.—Longibucca vivipara, new species.

The genus *Longibucca* is most closely related to the genus *Myctolaimus* Cobb, 1920 but differs from that genus in the presence of indistinct lips, and only one ovary. It differs from *Cylindrogaster* Goodey, 1927, in the following characters: In *L. vivipara* there is a single ovary, the vulva is in the posterior part of the body, and caudal alae are absent, while in *Cylindrogaster longistoma* there are two ovaries, the vulva is near the middle of the body, and caudal alae are present. The character of the buccal cavity in *L. vivipara* differs from that of *C. longistoma* only in the very delicate thickening of the anterior part in *L. vivipara.*

Longibucca vivipara, new species
(Figs. 7–10 and 19).

Specific description.—Longibucca: Male 500 to 550μ long by 10 to 12μ wide. Lateral alae present. Anterior part of buccal cavity 4.7μ, posterior part 55 to 60μ long. Esophagus consisting of a cylindrical corpus 18 to 20μ long by 4μ wide, an isthmus 22μ by 2μ wide, and a glandular pseudobulb, 16μ long by 4μ wide. Nerve ring 70 to 75μ, and excretory pore 65 to 75μ, from anterior end of body; tail curved, attenuated, usually having a dorsal turn near distal end. Caudal papillae consisting of six pairs, one pair preanal, five pairs postanal; second and fifth pairs subdorsal, others subventral. Testis single, outstretched, extending to within 224μ of anterior end of body. Spicules 13 to 17μ long; gubernaculum 4.5μ long.

Female 580 to 630μ long by 18 to 20μ wide. Anterior part of buccal cavity 4 to 4.5μ long; posterior part of buccal cavity 50 to 64μ long. Esophagus consisting of a corpus 20 to 25μ long by 3.5 to 4μ wide, an isthmus 18 to 20μ long by 1.5 to 2μ wide, and a glandular pseudobulb 15 to 18μ long by 5 to 6μ wide. Nerve ring 85 to 97μ and excretory pore 80 to 92μ from anterior end

of body, respectively. Tail curved, attenuated; usually having a dorsal turn near distal end. Vulva 480 to 520μ from anterior end of body (approximately 82 per cent of length from anterior end); vagina short, transverse; uteri divergent; anterior gonad outstretched, extending to within 160 to 200μ of anterior end of body; posterior uterus rudimentary, gonad absent. Eggs produced singly, shell thin; viviparous. Eggs grow in size with growth of larva.

Host.—*Pseudoboa cloelia.*

Location.—Stomach.

Distribution.—National Zoological Park, Washington, D. C. (Host from British Guinea).

Type specimens.—U. S. National Museum Helm. Coll. No. 33005; paratypes No. 33006.

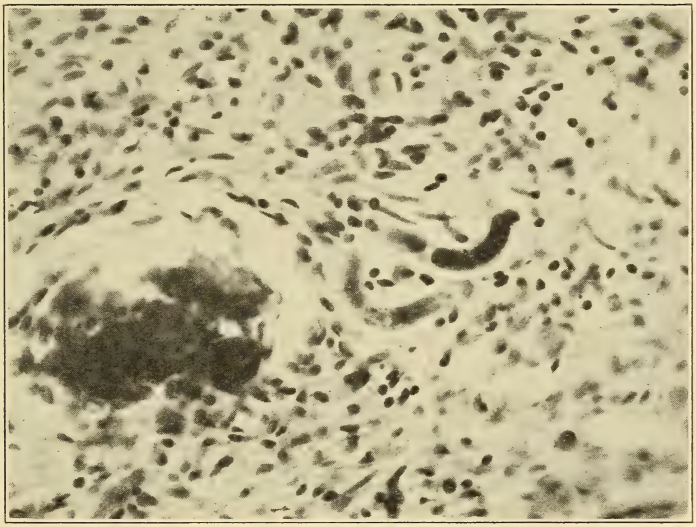


Fig. 19.—Section of stomach of *Pseudoboa cloelia* showing female *Longibucca vivipara* free in submucosa.

Sections were made of the stomach wall of the host, *Pseudoboa cloelia,* in which both larval and adult nematodes were observed in large numbers. These parasites were situated in the mucosa and submucosa, and some few were even observed in the muscular coat of the stomach. The nematodes were often free, apparently migrating through the mucous membrane and submucous coat, but some specimens were also observed partially coiled in and surrounded by tissue showing some slight cellular reaction. The stomach wall contained a great number of epithelial plugs and in some of these partially degenerate specimens of the parasite were observed (Figs. 19 and 20). The evidence at hand indicates that these worms exert a distinct pathological effect upon the host.

Goodey (1927) has suggested that the genus *Aulolaimus* de Man, 1884, might be related to *Cylindrogaster* Goodey, 1927.

The position of the genus *Aulolaimus* is uncertain at the present time. It presents similarities to the Cylindrogasteridae and the Monhysteridae (Cylindrolaiminae). DeMan states, "Kopfende nicht abgesetzt, ohne Lippen, Papillen oder Borsten. Mundhöhle ausserordentlich verlängert, röhrenformig, sehr enge, länger als der eigentliche Osophagus, mit chitinösen Wänden." In the figure of the esophageal region of the type species, *Aulolaimus oxycephalus*, a long tubular buccal cavity and a short cylindrical "esophagus" is shown. The possession of median preanal papillae in the male

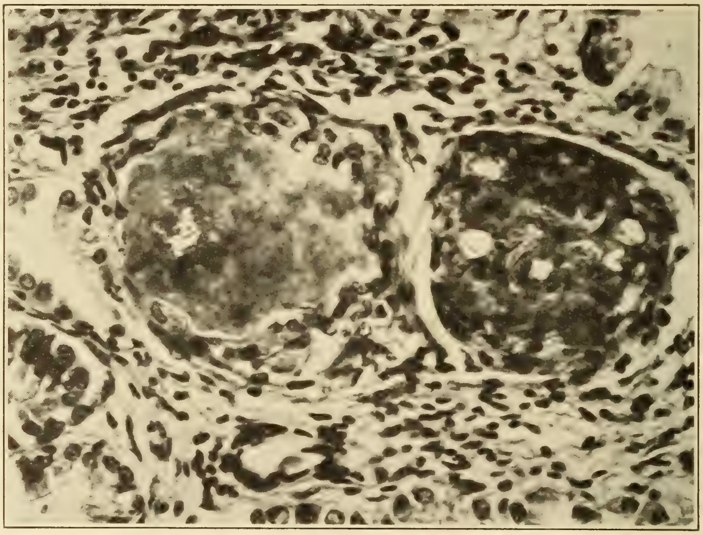


Fig. 20.—Section of stomach of *Pseudoboa cloelia* showing epithelial plug containing *L. vivipara*.

probably indicates a relationship with *Cylindrolaimus* de Man, 1880, rather than with *Cylindrogaster*. Since the description of the anterior end of the intestine and its connection with the esophagus is omitted, it seems possible that de Man overlooked the isthmus and glandular pseudobulb, thus concluding that the corpus was the entire esophagus. The distinguishing features of *Aulolaimus*, if it warrants consideration here as a member of the Cylindrogasteridae, are as follows: Caudal alae absent in male; spicules semicircular in contour; three large median preanal papillae; postanal papillae absent. Vulva slightly posterior to middle of body; amphidelphic. The present writer makes no assumptions or interpretations in regard to the original description and mentions only those characters which serve to distinguish the genus *Aulolaimus* from the four genera previously characterized as belonging to the Cylindrogasteridae.

Family RHABDITIDAE Oerley, 1880

RHABDITIS TERRICOLA Dujardin, 1845

(Figs. 11–14).

Synonyms.—Pelodera teres Schneider, 1866; *Rhabditis teres* (Schneider, 1866) Bütschli, 1873.

Specific description.—Rhabditis: Oral opening surrounded by six distinct lips, the internal sides of which are abruptly triangular. Internodorsal, internolateral and internoventral papillae well developed; laterodorsal, and lateroventral papillae well developed; dorsodorsal, ventrolateral, and ventroventral papillae somewhat reduced. Amphids represented externally by small pores situated dorsolaterally on the lateral lips. Cuticle with longitudinal rows of minute dots.

Male 830μ to 1.14 mm. long by 48 to 64μ wide. Buccal cavity 18 to 20μ long by 4 to 5μ wide. Glottoid apparatus consisting of nine elements (Fig. 13). Esophagus consisting of a corpus 86 to 100μ long by 10 to 12μ wide, subdivided into an anterior part 58 to 66μ long by 10 to 12μ wide, and a corporeal swelling 28 to 34μ long by 20 to 24μ wide, an isthmus, 30 to 32μ long by 6 to 8μ wide, and a bulb 28 to 30μ long by 24 to 26μ wide. Nerve ring 110μ from anterior end of body. Excretory pore 144μ from anterior end of body. Excretory system consisting of paired anterior and posterior collecting ducts which join ventrally in the region of the bulb, forming a sinus, two subventral gland cells which likewise open into the sinus, and a cuticular-walled, terminal duct. Anterior part of intestine enlarged but not set off as a distinct area or cardia; intestinal pigment very dark, nearly black; anus 26 to 40μ from posterior end of body. Testis single, extending to within 350 to 470μ (41 to 42 per cent) of the anterior end of the body, reflexed posteriorly. Two large multicellular ejaculatory glands present. Caudal alae surround tail to form a rhabditoid bursa. Caudal papillae consisting of 10 pairs of papillae, 3 pairs preanal, 7 pairs postanal. There is a minute medioventral preanal organ, a pair of preanal subventral papillae, and a pair of postanal subventral papillae on the cloacal elevation; postanal papillae indistinct, possibly double (Fig. 14). Spicules 36 to 42μ long, fused distally, cephalated proximally; gubernaculum closely applied to spicules.

Female 1 to 1.35 mm. long by 66 to 70μ wide. Buccal cavity 22 to 26μ long by 6μ wide. Esophagus consisting of a corpus 86 to 100μ long, subdivided into an anterior part 62 to 70μ long by 10 to 12μ wide and a corporeal swelling 24 to 30μ long by 20 to 22μ wide, an isthmus 34 to 42μ long by 7 to 8μ wide, and a bulb 30μ long by 28μ wide. Nerve ring 130 to 146μ, and excretory pore 154 to 170μ, from anterior end of body, respectively. Intestine as in male; anus 48 to 76μ from posterior end of body. Tail blunt with a filiform terminus. Vulva 540 to 730μ from anterior end of body (53 to 55 per cent); vagina transverse; uteri opposed. Anterior ovary reflexed posteriorly, extending to within 330 to 400μ of anterior end of body (29 to 33 per cent); posterior ovary extending to within 186 to 201μ of posterior end of body (15 to 18.6 per cent), reflexed anteriorly. Eggs 36 to 44μ long by 18 to 26μ wide; ovoviviparous; eggs numerous, up to 18 in number.

Host.—Salamandra salamandra.

Location.—Lung.

Locality.—National Zoological Park, Washington, D. C.

Specimens.—U. S. National Museum Helm. Coll. No. 33007.

This species was found in large numbers in the lung of a single specimen of *Salamandra salamandra;* probably this host and location represent an accidental or abnormal habitat for this nematode which is usually found in decaying plant or animal tissue. It is possible also that the invasion may have taken place after death of the host.

Micoletzky (1922) refers to *Rhabditis terricola* Dujardin, 1845, as a synonym of *Rhabditis teres* (Schneider, 1866), stating that Dujardin's species must be considered as a species inquirenda. This is an untenable conclusion, since if *Rhabditis terricola* Dujardin is a species inquirenda, the genus *Rhabditis* Dujardin, 1845, of which *R. terricola* is the type, must also be regarded as a genus inquirenda. Oerley (1886) considered *R. teres* (Schneider) a synonym of *R. terricola* Dujardin, and this conclusion appears to be the most reasonable solution. In his discussion, Dujardin undoubtedly referred to a number of species, and in the description only 7 or 8 pairs of caudal papillae are mentioned. There are discrepancies in the number of caudal papillae as found by subsequent workers, but these discrepancies do not appear to be greater than those found in the works of Rudolphi, Diesing, and other of the earlier helminthologists. The genus *Rhabditis* is old and very well known, and *R. terricola* (=*R. teres* [Schneider]) is a very common species, available to workers in all parts of the world. In synonymizing *R. teres* with *R. terricola*, Oerley made an assumption which would validate this genus and there can be no doubt concerning the genus so long as he is followed. On the contrary, if many of the descriptions of older genera and species were held to the exact statements made by the author, probably over half of the genera today would necessarily become invalid, with a resultant confusion and little or no benefit.

RHABDITIS LUCANII Maupas, 1919
(Figs. 15–18).

Specific description.—Rhabditis: Oral opening subtriangular, surrounded by three bilobed lips (formed by the fusion of six lips). Internal circle of papillae well developed. Dorsodorsal and ventroventral papillae small, near large laterodorsal and lateroventral papillae; ventrolateral papillae small. Amphids slightly subdorsal.

Male 1 to 1.32 mm. long by 64 to 94μ wide. Buccal cavity 20 to 22μ long by 5 to 6μ wide. Glottoid apparatus distinct. Esophagus consists of a corpus 126 to 140μ long, indistinctly subdivided into an anterior part 70 to 80μ long by 18 to 20μ wide, and a corporeal swelling 56 to 60μ long by 24 to 26μ wide, an isthmus 50 to 54μ long by 11 to 14μ wide, and a bulb 24 to 35μ long by 28 to 34μ wide. Nerve ring 156 to 180μ from anterior end of body. Excretory pore 180 to 230μ from anterior end of body. Excretory system consisting of paired anterior and posterior collecting ducts which join ventrally in the region of the esophageal bulb, forming a sinus, two subventral excretory glands which likewise open into the sinus, and a cuticular-walled terminal duct. Anterior part of intestine not enlarged; anus 44 to 60μ from posterior end of body. Testis single, extending to within 370 to 454μ of anterior end of body; ejaculatory glands apparently absent. Caudal alae

large, nearly united to form a rhabditoid bursa but not surrounding tail, terminus of tail extending beyond bursa as a fine filament. Caudal papillae consisting of 9 pairs of which 3 pairs are preanal, 3 pairs adanal and 3 pairs postanal. Phasmids (sometimes also referred to as papillae) immediately posterior to last pair of caudal papillae. Fifth and eighth pairs of papillae terminating on dorsal side of bursa (Fig. 18). One pair of small preanal subventral papillae and a pair of double postanal subventral papillae near anus. Spicules separate, 50 to 62μ long, only slightly cephalated, proximally not arcuate, slightly hooked distally; gubernaculum 20 to 27μ long.

Female 1.36 to 1.45 mm. long by 114 to 120μ wide. Buccal cavity 20 to 26μ long by 55 to 64μ wide. Esophagus consists of a corpus 130 to 170μ long, subdivided into an anterior part 76 to 90μ long by 20 to 26μ wide and a posterior corporeal swelling 54 to 80μ long by 30 to 32μ wide, an isthmus 54 to 80μ long by 12 to 15μ wide, and a bulb 30 to 50μ long by 32 to 36μ wide. Nerve ring 160 to 210μ, and excretory pore 210 to 250μ, from anterior end of body, respectively. Excretory system consists of a pair of anterior and posterior collecting ducts which join anteriorly to form a sinus, a pair of subventral glands which open into the sinus, and a terminal, cuticular-walled duct; posterior excretory system also present. Intestine as in male; anus 120 to 180μ from posterior end of body. Tail conically attenuated. Phasmids (lateral tail "papillae") 82 to 130μ from posterior end of body. Vulva 670 to 732μ from anterior end of body (49 to 50 per cent of body length from anterior end); vagina short, transverse, uteri opposed; anterior ovary extending to within 420 to 580μ of anterior end of body, reflexed posteriorly; posterior ovary extending to within 510 to 520μ of posterior end of body, reflexed anteriorly. Eggs 50 to 52μ long by 28 to 30μ wide; ovoviviparous; total number of eggs usually about 6 to 10.

Host.—*Salamandra salamandra.*

Location.—Lung.

Locality.—National Zoological Park, Washington, D. C.

Specimens.—U. S. National Museum Helm. Coll. No. 33008.

Rhabditis lucanii, like *R. terricola*, was found but one time in the lungs of *Salamandra salamandra.* The writer has no absolute proof that this species did not invade the body of the host after death even though the carcass was in good condition, but since there were several hundred specimens of *R. lucanii* present, the conclusion that this was not a case of post-mortem invasion appears reasonable under the circumstances.

The species *Rhabditis lucanii* Maupas, 1919, was proposed for *Rhabditis aspera* Bütschli, 1873, of Oerley, 1886, the chief differences between *R. aspera*, as originally described by Bütschli (1873), and as described by Oerley (1886) = *R. lucanii* Maupas, 1919, being that the swelling of the anterior part of the esophagus is less distinct and the spicules are thinner in *R. lucanii* than in *R. aspera*.

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ZOOLOGY.—*New species of Lymnaeidae from British America.*[1]

FRANK COLLINS BAKER, University of Illinois. (Communicated by PAUL BARTSCH.)

The receipt of a number of species of Lymnaeidae from British America submitted by the Geological Survey of Canada for identification has made necessary a revision of most of the species belonging to the genus *Stagnicola.* In the course of this revision it became apparent that a number of species were passing current under names which did not belong to them. One of these is *Lymnaea* (*Stagnicola*) *vahlii* (Beck) Möller. An examination of the material belonging to this species contained in the United States National Museum, named by Mörch, seems to indicate rather conclusively that *vahlii* is not found outside of Greenland, its type locality. Both Dall (Alaska Moll., p. 74, 1905) and Baker (Lymnaeidae of North America, p. 370, 1911) refer material from various parts of British America to *vahlii.* As many as ten species appear to have been included in this species. From an examination of an abundance of material from different parts of Canada and adjacent territory it may safely be stated that *vahlii* must be restricted to Greenland and that these other species and forms must be given names. The only lymnaeid approaching *vahlii* is *Stagnicola arctica* (Lea), described from Moose River at Moose

[1] Received August 3, 1933.

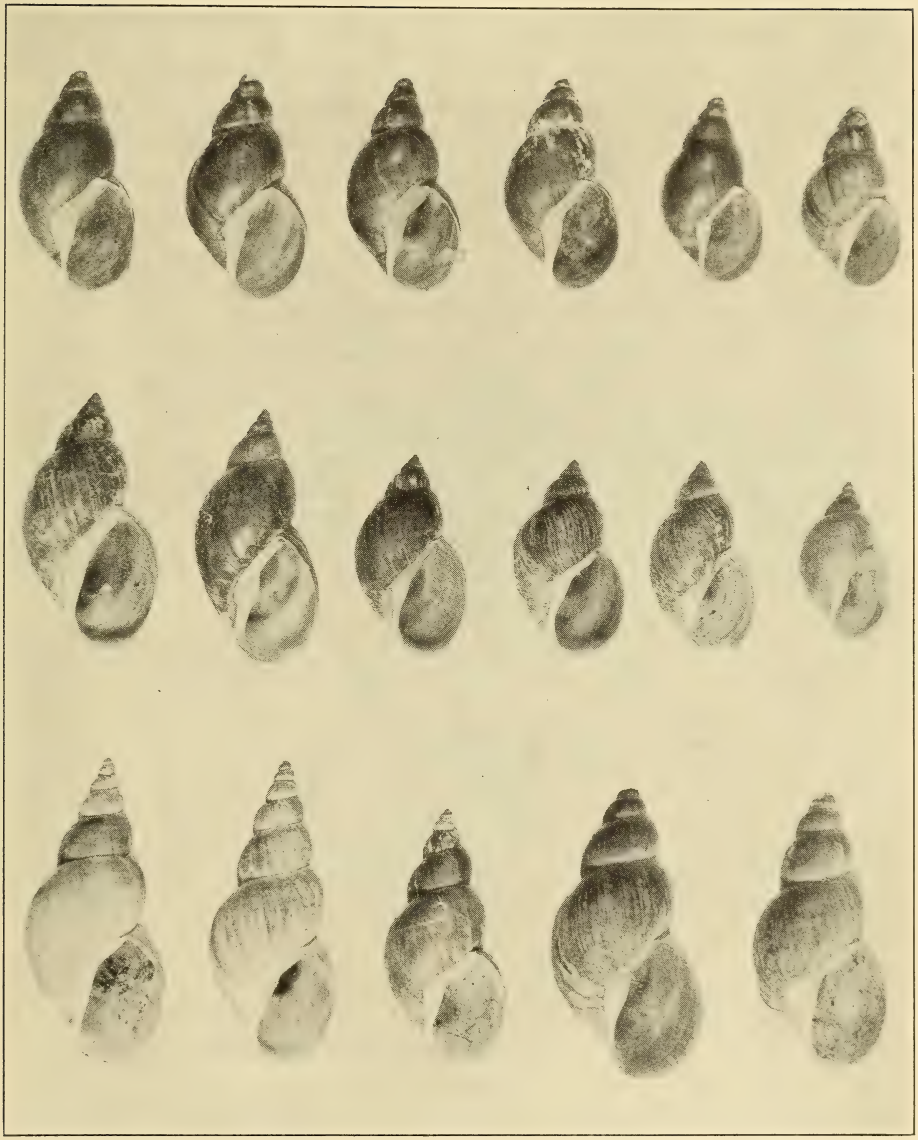

Fig. 1.—Upper row, *Stagnicola vahlii,* Greenland; middle row, *S. arctica,* Moose River, Hudson Bay; lower row, three figures at left, *S. kennicotti* (middle figure the holotype), two figures at right, *S. palustris ungava* (figure at left holotype). All figures ×2.

Factory, Hudson Bay. For comparison figures of *vahlii* are shown in Fig. 1, the upper row. These are from Greenland and were named by Mörch. Specimens of *arctica* from the type locality are shown in the second row, collected by Mr. Calvin Goodrich. This species has a differently shaped shell and aperture.

Two new forms found in the material submitted by the United States National Museum are described below. A full discussion of the British American lymnaeid fauna is in preparation.

Stagnicola kennicotti, sp. nov.

Fig. 1, lower row, three figures at left.

Shell elongated, turreted, rather solid; light horn colored, whitish and greenish in some specimens; surface dull, growth lines coarse and spiral lines deeply indented; whorls 7, convex, the body whorl globose, the sutures deeply indented; spire acutely pyramidal, considerably longer than the aperture; nuclear whorl large, flattened, horn-colored; aperture roundly ovate; outer lip thin with slight or no varical thickening; inner lip flattened but not very wide and reflexed over the umbilical region, leaving a small, narrow chink; the inner lip spreads upward to form a callus on the parietal wall; there are several varical bands on the shell, usually dark brown in color.

Length	21.3;	Diameter	9.0;	Aperture	length	8.9;
"	21.5;	"	10.0;	"	"	9.5;
"	17.6;	"	8.3;	"	"	7.8;

Diameter	4.5 mm.	Holotype.
"	5.0 mm.	Paratype.
"	4.7 mm.	Paratype.

Type Locality: Creek at Barnard Harbor, near Coronation Gulf, Mackenzie District, Canada. *Types:* U.S. Nat. Mus., No. 216856, collected by Canadian Arctic Expedition. Another lot of 5 specimens, immature, No. 216855.

This lymnaeid differs from all others in the Canadian region in its scalar whorls, small, roundly ovate aperture, and convex whorls. It belongs to a peculiar group of species distributed throughout northwestern Canada and Alaska which have passed for *vahlii*, but which represent several distinct species and races. Young shells of *kennicotti* 11–12 mm. long are very scalariform and have $5\frac{1}{2}$ whorls. The same difference in length of aperture and spire persists in the immature shell as it does in the mature shell of seven whorls.

This species is dedicated to Robert Kennicott, a distinguished naturalist of the middle of the last century, who greatly advanced the study of arctic life by his personal explorations and who died in Alaska on his last expedition.

Stagnicola palustris ungava, subsp. nov.

Fig. 1, lower row, two figures at right.

Stagnicola vahlii Dall, Alaska Moll. 75. 1905; Baker, Lymnaeidae, 372. 1911.

Shell rather thin, elongated; color brownish horn, sometimes streaked with yellowish, the streaks often arranged in longitudinal bands; surface dull, sculpture of coarse growth lines and impressed spiral lines; whorls more than 6 (the apex is broken in all specimens), quite convex with deep sutures; body whorl obese; spire broadly pyramidal, elongated, longer than the aperture; the penultimate whorl is large and puffy in appearance; aperture roundly ovate, rounded below and a trifle acute above, light chocolate colored within; outer lip thin without varical thickening in adult shells; inner lip wide, folded over the columellar region to form a wide reflection which is impressed and indented at the junction of columella and body whorl; there is no distinct plait; there is a narrow umbilical chink; parietal wall with a wide, white callus.

Length	20.2;	Diameter	10.0;	Aperture	length	10.2;	Diameter 5.6 mm. Holotype.
"	19.0;	"	9.1;	"	"	8.6;	" 5.0 mm. Paratype.
"	19.5;	"	9.0;	"	"	9.0;	" 5.3 mm. Paratype.

TYPE LOCALITY: Fort Chimo, Kuksoak River, near Ungava Bay, Labrador, collected by Turner. *Types:* U.S. Nat. Mus., No. 73727.

This lymnaeid appears to be a member of the *palustris* complex, differing from the race called *elodes* in its globose body whorl, smaller and rounder aperture, less distinct columellar plait, larger umbilical chink, and the puffy appearance of the penultimate whorl. It has not been seen from any other part of British America and may be a distinct northeastern race of *palustris*.

ZOOLOGY.—*A new puma from Brazil.*[1] E. W. NELSON and E. A. GOLDMAN.

The examination of material recently received from the field, has indicated the desirability of recognizing a geographic race of *Felis concolor* Linné in the great lowland area embraced in the Amazon River drainage, northern Brazil. The specimens are in the American Museum of Natural History, New York. For the privilege of describing the new form we are indebted to Messrs. H. E. Anthony, Curator of Mammals, and G. H. H. Tate, Assistant Curator of South American Mammals, in the institution mentioned.

[1] Received July 28, 1933.

Felis concolor borbensis, subsp. nov.

Amazon Puma

Type.—From Borba, Rio Madeira, Amazonas, Brazil. No. 92298, ♂ adult, skull only, American Museum of Natural History, collected by Olalla Brothers, February 10, 1930. Original No. 1854.

Distribution.—Middle section of low valley of Amazon River to upper course of Rio Negro; probably widely distributed in low lying parts of Amazon River drainage.

General characters.—A medium sized, rich rufescent subspecies, closely allied to *Felis concolor concolor* of southeastern Brazil, but darker cinnamon rufous or ferruginous, and cranial details distinctive. Similar in color to *F. c. anthonyi* of southern Venezuela, but skull decidedly narrower, less massive. Differing from *F. c. wavula* of British Guiana, in smaller size and important cranial features. Much larger and darker than *F. c. greeni* of Rio Grande do Norte, extreme eastern Brazil, and skull characters widely divergent.

Color.—Female from Rosarinho, Rio Madeira, Brazil: Top of head, neck, and narrow median dorsal area to base of tail rich cinnamon rufous thinly overlaid with black, passing gradually on sides of neck, shoulders, along flanks and on outer surfaces of limbs, into cinnamon, becoming cinnamon buff across under surface of neck and on feet; chin, throat, chest, inner sides of limbs, inguinal region and lips, except a black spot near vibrissae, white; belly pale buffy; face in general dark brownish, almost blackish on upper surface of muzzle; ears deep glossy black externally, narrowly edged with gray, thinly clothed internally with whitish hairs; tail above tawny on proximal half and ochraceous tawny on distal portion, mixed with black, becoming light ochraceous buffy below to near black tip. In a specimen from Aurará Igarapé the median dorsal area is darker and nearer ferruginous.

Skull.—Very similar in general form to that of *F. c. concolor,* but decidedly narrower; rostrum narrower; nasals rising higher between anterior processes of frontals as viewed in profile from the side, the median trough-like depression deep anteriorly much as in *concolor,* but shallowing more rapidly posteriorly; posterior border of palate more convex; interpterygoid fossa narrower; audital bullae smaller; upper carnassials and third upper molars smaller. Much narrower, less massive than *F. c. anthonyi;* frontal region higher, more evenly arched; nasals less flattened, more inflated and convex between anterior processes of frontals as viewed from the side; rostrum and interpterygoid fossa much narrower; audital bullae smaller; carnassials and third premolars, above and below, distinctly smaller. Smaller and lighter in structure than *F. c. wavula;* rostrum less compressed laterally between ascending branches of maxillae; nasals more highly arched, less depressed and V-shaped along median line posteriorly; interpterygoid fossa relatively narrower; audital bullae relatively smaller; dentition much lighter; upper carnassial with internal cusp less prominent. Contrasted with that of *F. c. greeni* the skull exhibits a marked departure in detail, as follows: Size larger; general form more elongated; vault of cranium much higher, more arched; nasals more inflated, less flattened; ascending branches of maxillae narrower; audital bullae relatively larger, more inflated; dentition relatively heavier; canines relatively much longer.

Measurements.—An adult female from Rosarinho, Rio Madeira, Brazil: Total length, 1500 mm.; tail vertebrae, 693; hind foot, 220. *Skull* (type):

Greatest length, 200; zygomatic breadth, 135.7; interorbital breadth, 41.7; least width between outer walls of interpterygoid fossa, 28.2; alveolar length of upper canine-premolar series, 59.2; crown length of upper carnassial, 23.3.

Remarks.—*Felis concolor borbensis* will probably prove to be widely distributed in the vast lowland area drained by the Amazon River and its tributaries. Specimens from the region of the type locality appear to be more nearly related to *F. c. concolor* than to any other known form, but the scanty material available indicates that the cranial details mentioned are quite distinctive. One from Tatú, in the lowlands of the upper part of the Rio Negro, near the mouth of the Rio Uaupes, is not very far distant geographically from *F. c. anthonyi*, but agrees closely in the more essential characters with typical *borbensis.* The new form, *borbensis,* occupies a somewhat intermediate geographic position and may be expected to intergrade on the north with *anthonyi* and *wavula,* on the east with *greeni,* on the south with typical *concolor,* and on the west it may possibly pass into *F. c. söderströmii,* the dark, high mountain form of northern Ecuador.

Specimens examined.—Four, all from Brazil, as follows: Aurará Igarapé, Rio Madeira, 1; Borba, Rio Madeira (type locality), 1; Rosarinho, Rio Madeira, 1; Tatú, Rio Negro, 1.

ZOOLOGY.—*A new climbing mouse from Panama.*[1] E. A. GOLDMAN, Biological Survey.

In the course of studies of the mammals of Barro Colorado Island, Canal Zone, Panama, Robert K. Enders obtained, in a tree, a single specimen of a new form closely allied to *Oecomys bicolor*, of Ecuador. For the privilege of describing the new species I am indebted to Dr. Enders for whom the animal is named.

Oecomys endersi, sp. nov.

Barro Colorado Island Climbing Mouse

Type.—From Barro Colorado Island, Canal Zone, Panama. No. 64931, ♀ adult, University of Michigan Museum, collected by R. K. Enders, February 12, 1931. Original number 474.

Distribution.—Known only from the type locality.

General characters.—A medium-sized, dark-colored species, with tail somewhat longer than head and body, slightly pencilled at tip; zygomata slightly notched and zygomatic plate little projecting anteriorly, as viewed from above. Mammae: Pectoral, 2–2, inguinal, 2–2, = 8. Closely allied to *Oecomys bicolor* of Ecuador, but larger and darker, with correspondingly larger skull.

Color.—*Type:* Upper parts near cinnamon brown (Ridgway, 1912) rather heavily mixed with black, the general tone richest or most rufescent on lower part of back and rump, paling gradually to dull cinnamon buff or clay color along lower part of sides; under parts and inner sides of limbs nearly pure white, the hairs white to roots; ears dark brownish, thinly

[1] Received August 24, 1933.

clothed with minute dusky hairs; outer sides of forearms dusky; fore and hind feet dull whitish, the hind feet with a trace of brownish on metatarsus; tail dark brownish above, somewhat lighter below, nearly naked and finely scaly, with a slight tuft of dark hairs at tip.

Skull.—Closely resembling that of *O. bicolor*, but larger and heavier.

Measurements.—*Type:* Total length, 238 mm.; tail vertebrae, 124; hind foot, 25; ear, 15. *Skull* (type): Occipitonasal length, 28: zygomatic breadth, 15; interorbital breadth, 5.3; breadth of braincase (at constriction in front of lateral occipital crests), 11.5; length of nasals, 10.2; anterior palatine foramina, 4.3; palatal bridge, 5.2; maxillary toothrow, 4.

Remarks.—The type of *Oecomys endersi* has been compared with specimens from Pambilar, northern Ecuador, examined and marked simply "dryas" by Oldfield Thomas many years ago. The specimens agree closely with the description of *Rhipidomys dryas* Thomas, from Paramba, northern Ecuador, and he doubtless had that species (not *Oryzomys dryas* Thomas) in mind. Thomas has since (Ann. Mag. Nat. Hist., ser. 7, **18**: 445. 1906) regarded *Rhipidomys dryas* as probably the same as *Oecomys bicolor* (Tomes).

The new form differs from *bicolor* mainly in size and may prove to be only a geographic race of a widely distributed species of this relatively little known group. It requires no close comparison with the much smaller species, *O. trabeatus*, of eastern Panama.

The genus *Oecomys* seems to be based on rather slight differential details. It is very similar to *Oryzomys*, in many characters, including dentition and the possession of two pairs of pectoral mammae, but it differs in the anterior truncation of the zygomatic plate. The short, broad hind feet and sharp, strongly curved claws, adapted for climbing are shared with such species as *Oryzomys tectus*, also of Panama, which is normal in the Oryzomyine development of the zygomatic plate.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1046TH MEETING

The 1046th meeting was held jointly with the Washington Academy of Sciences in the Cosmos Club Auditorium, Thursday evening, December 15, 1932, L. H. ADAMS, President of the Academy, presiding.

The program consisted of an address by PAUL R. HEYL, of the Bureau of Standards, entitled *Romance or science?* The address has since been published in full in this JOURNAL **23**: 73–83. 1933.

Discussed by Mr. HULBURT.

1047TH MEETING

The 1047th meeting was held in the Cosmos Club Auditorium, January 14, 1933, President O. S. ADAMS, presiding.

Program: The address of the retiring president, L. B. TUCKERMAN, entitled *From material to structure.* This address has since been published in full in this JOURNAL **23**: 225–246. 1933.

1048TH MEETING

The 1048th meeting was held in the Cosmos Club Auditorium, January 28, 1933, President O. S. ADAMS presiding.

Program: E. O. HULBURT: *The use of the bubble sextant at sea.*—It is well known that on a ship at sea an artificial horizon, such as a pool of mercury or a bubble in a liquid like a spirit level, is unsteady because of the motion of the ship. Altitudes measured from the artificial horizon are not very accurate, and this disadvantage has been great enough to prevent its use at sea almost entirely. In recent years, however, the bubble sextant has been brought to a fairly high state of perfection due to the demands of aviation. Little information was available about the use of the later types of bubble sextants on surface ships and the present experiments were carried out to find out how useful they might be.

Observations were made from a 1,000 ton and a 12 ton ship underway at sea. It was found of course that the errors of the bubble sextant altitudes increased with the roughness of the sea. In a moderate sea errors of individual altitudes were sometimes as great as 60 minutes of arc, but averages of 5 consecutive observations were usually correct to within 30 minutes of arc.

A considerable portion of the bubble sextant error is due to the accelerations arising from the roll of the ship; this is especially true on a large ship. The error is at its minimum when the ship is at the mid-point of its roll or pitch. A simple pendulum device, called the "mid-point indicator," was arranged to sound a short buzzer signal when the ship passed through the mid-point of the roll. The bubble sextant observations were taken when the buzzer sounded. This called for an adjustment of the simultaneous coincidence of three moving things, bubble, buzz, and the image of the celestial object, which in practice was easy to do. It was found that the mid-point indicator reduced the bubble sextant errors by perhaps a half. On a large ship the improvement due to the indicator might be even more. (*Author's abstract.*)

Discussed by Messrs. TUCKERMAN, WENNER, SNYDER, WRIGHT, BRECKENRIDGE, HUMPHREYS, and BRICKWEDDE.

F. E. FORBUSH: *Gravity-determinations on the "Carnegie."*—The importance of gravity-measurements at sea for the purpose of deriving an accurate figure of the Earth was emphasized. The value of detailed gravity-surveys in yielding information concerning phenomena in the Earth's crust was pointed out by a brief review of the research of Dr. F. A. Vening Meinesz on the gravity-anomalies of the Dutch East Indies. At this point, mention was made of the possibility of some connection between the causes of gravity-anomalies and the causes of the irregular geographical distribution of secular variation, as was indicated by Professor S. Chapman.

The methods involved in eliminating the principal effects of a ship's movements upon the motion of an ordinary pendulum were reviewed. Particular attention was paid to the method of eliminating the principal disturbance which is due to the horizontal accelerations of the pendulum-support, by recording photographically the difference in the angles of elongation of two nearly isochronous pendulums.

The means of obtaining the various corrections to the pendulum-periods from the photographic record were briefly indicated. A description of the main features of the apparatus followed. To this point the report was essentially a brief review of (1) *Gravity anomalies in the East Indian Archi-*

pelago, a paper read by Dr. Meinesz before the Royal Geographical Society of London on November 10, 1930; (2) a publication by Dr. Meinesz on *Theory and practice of pendulum observations at sea;* and (3) *The gravity-measuring cruise of the U.S. submarine S-21*, a U.S. Naval Observatory Publication by Dr. Meinesz and Dr. F. E. Wright.

The installation of the apparatus on the "Carnegie" was then described. Photographic records for determinations of gravity obtained on the "Carnegie" at sea were shown and discussed. The agreement between the "Carnegie" determinations of gravity in San Francisco and in Honolulu and the values previously obtained in those ports by Dr. Meinesz with another apparatus of the same type was indicated. This was followed by a short discussion of the isostatic anomalies as computed by the U.S. Coast and Geodetic Survey for three of the "Carnegie" stations.

Finally, it was indicated that the loss of the vessel so soon after the installation of the apparatus in San Francisco hardly afforded sufficient opportunity to advance the work beyond the experimental stage. Thus, while the contribution in number of new gravity-stations was not great, the experience showed that it is possible to obtain accurate values of gravity with the Meinesz apparatus on board surface vessels. (*Author's abstract.*)

Discussed by Messrs. WILLIS, HAWKESWORTH, DUERKSEN, and H. L. CURTIS.

An informal communication entitled *The natural philosophy of generalized money* was presented by J. E. WILLIS.

1049TH MEETING

The 1049th meeting was held in the Cosmos Club Auditorium, February 11, 1933, President O. S. ADAMS presiding.

Program: Rev. F. W. SOHON, S.J.: *The seismic receiver.* Published in this JOURNAL **23**: 409. 1933.

Discussed by Mr. HECK.

FRANK NEUMANN: *The interior of the earth as revealed by seismological data.*—An outline was given of the development of instrumental seismology and the interpretation of data relating to the interior structure of the earth. It included an explanation of the methods used in locating discontinuities and stressed the problems and uncertainties involved in the construction of smooth travel-time curves for seismic waves. Variations in the curves drawn for different shocks were charged to varying focal depths and regional variations in velocity through the crustal layers.

Travel-time data for the Santiago (Cuba) earthquake of February 3 were exhibited, and it was shown that there was reasonable justification for breaking the curve into about five elements, possibly disconnected. Assuming the extreme case that the curve was composed of a series of practically straight line elements, overlapping at definite points, it was shown how discontinuities could be located on the hypothesis that the earth is composed of a number of concentric shells, in each of which the velocity is practically constant regardless of depth. Preliminary computations gave discontinuities close to the major discontinuities generally recognized at depths near and greater than 1200 km. At shallower levels, however, there are two or more sets of direct waves having trajectories differing radically from the system of fan-shaped rays based on the prevailing theory of continuous velocity increase with depth. A discontinuity is indicated at a depth of about 400 km. This corresponds to one reported by Mohorovicic. It happens by chance that

trajectories based on the theories of continuous refraction and discontinuous refraction have practically the same limiting dimensions for the critical arc distance of about 20° where a sharp bend in the travel time curve indicates a discontinuity.

Activities appear on the seismograms, after the onset, which might be interpreted as direct waves of slower travel time. They could be taken as a verification, or partial verification, of the discontinuous refraction hypothesis, but the author is not inclined to consider them as such without additional supporting data. The uncertainties involved in seismogram interpretation were stressed. The rather constant character of the observed angle of emergence (as reported by Galitzin) between 2500 km. and 6000 km. is cited as evidence supporting the hypothesis of discontinuous refraction. The theory of continuous refraction calls for an increase of about 20° in this zone. No systematic observational data are available on the angle of emergence at distances less than 2500 km.

Interesting as these results are, it was pointed out that seismologists often have difficulty in reconciling the travel-time data compiled for different shocks and, until this difficulty is overcome there will always be a serious element of uncertainty in conclusions based on seismographic data. The hypothesis discussed represents an extreme case and it is quite possible that the true nature of velocity variation will eventually be found to contain the elements of both theories; that is, refraction of the seismic wave within a limited zone may be either continuous, or discontinuous in type. (*Author's abstract.*)

Discussed by Mr. L. H. Adams.

1050th meeting

The 1050th meeting was held in the Cosmos Club Auditorium, February 25, 1933, President O. S. Adams presiding.

Program: F. D. Murnaghan, Professor of Applied Mathematics in the Johns Hopkins University: *The mathematics of the expanding universe.*

Discussed by Messrs. M. Liferock, L. H. Adams, H. L. Curtis, J. H. Taylor, A. S. Hawkesworth, T. Dantzig, and Banes.

Informal communication: P. R. Heyl: *A new correction for the pendulum.*—It was brought out that the length of a fused quartz pendulum, measured in air, changes sufficiently when the pendulum is swung in a vacuum to introduce an appreciable error in the determination of gravity by this method. It was reported that the measured change in length of a quartz pendulum for a change in pressure of one atmosphere at atmospheric pressure was one half part in a million whereas the change in length calculated upon the basis of compressibility measurements made at high pressures was one part in a million.

1051st meeting

The 1051st meeting was held in the Cosmos Club Auditorium, March 11, 1933, President O. S. Adams presiding.

Program: Professor K. T. Compton, President of the Massachusetts Institute of Technology, delivered the third Joseph Henry Lecture, given in memory of the first president of the Philosophical Society of Washington. This lecture entitled *High voltage* was published in this Journal **23**: 277–297. 1933.

1052ND MEETING

The 1052nd meeting was held in the Cosmos Club Auditorium, March 25, 1933, President O. S. ADAMS presiding.

Program: Two illustrated lectures by M. A. TUVE and L. R. HAFSTAD on *Atomic nuclear studies at the Department of Terrestrial Magnetism.*—In the recent Joseph Henry lecture of the Society, Dr. K. T. Compton described methods of producing high voltages and indicated that one of the most fruitful applications of developments in this field would be in the study of the atomic nucleus. After indicating the relations of nuclear physics studies to other fields of research, especially in connection with our understanding of the basic phenomenon of magnetism, Dr. Tuve described experiments which have been under way since 1926 at the Department of Terrestrial Magnetism looking toward the utilization of high voltages in nuclear physics studies. An inexpensive Tesla-coil was used in the original experiments. By 1930 multiple section cascade tubes had been developed which withstood potentials up to two million volts. Positive particles and electrons accelerated through the tubes were found to have energies, as measured by electric and magnetic deflection, corresponding to the applied voltages and were thus analogous to the α and β-rays from radium. X-rays were also produced with absorption coefficients corresponding to the x-rays from radium. Thus all the radiations emitted by radium were approximately reproduced by the use of high-voltage tubes.

That the short on-time of the Tesla coil is a serious limitation in its application to nuclear problems was recognized from the beginning of the work and when the van de Graaff electrostatic generator was announced in 1931 tests were immediately begun in order to determine its usefulness in this field. Preliminary tests indicated that this device should prove to be a nearly ideal, low-cost voltage source for nuclear studies. A generator was built with a 2-meter sphere which attained a potential of about 2 million volts in tests out of doors. A potential of 1 million volts was applied to a vacuum tube, the applied potential being limited only by the length of the tube. Pending provision of suitable housing for this large generator, a smaller one, 1 meter in diameter, was constructed, which could be operated in the space available. With a height of 12 feet from the floor, to rafters 8 feet apart, a maximum potential of 750 kilovolts was obtained (measured by a generating voltmeter, checked by sparks to a 2-meter sphere, and roughly checked by magnetic deflection of the ions from the tube). A 12-inch silk belt running at 5000 feet per minute gave a charging current of 200 milliamperes.

Using a low voltage arc as a source, protons accelerated through a vacuum tube, operating at 600 kilovolts, have been used to bombard various elements, the disintegrations produced being observed by means of a linear pulse-amplifier. Lithium gives two alpha-particle groups, the shorter of approximately 19 mm. range, in about equal number. The boron yield is about 20 times that of lithium, in two groups, the shorter 28 mm. groups preponderating. About 4,000,000 protons strike the target for each alpha-particle of boron. These results are in agreement with those recently reported by Cockcroft and Walton (Cambridge). Studies of heavier elements are now in progress. For aluminum and nickel the yields are much lower than those reported last year by Cockcroft and Walton. With Al, for instance, target currents exceeding 10 microamperes of 600 kilovolt protons give about 7 counts per minute, or less than 0.7 counts per minute per microampere at this voltage. Because of their comparatively enormous yields, a very slight contamination of lithium or boron in the aluminum target would give rise

to this small number of counts. Whether the ranges of the observed particles from Al correspond to those of it or B has not yet been determined. Cockcroft and Walton reported 135 scintillation-counts per minute per microampere with a similar geometrical arrangement, using only 300 kilovolt protons. Thus it appears from our present results that the scintillation-counts observed by Cockcroft and Walton cannot be assigned to the disintegration of aluminum nuclei.

In the second paper Mr. Hafstad discussed the problem of resonance disintegration of aluminum as a typical example showing the way in which nuclear studies give a direct test of the ideas underlying the modern wave mechanics theory. From experiments on the scattering of α-particles, the form of the potential barrier surrounding the nucleus is known. On classical theory it is quite impossible for any particle to cross the barrier if its energy is less than that corresponding to the top of the barrier. On this older theory any particle escaping from the nucleus should have an energy at least equal to the maximum of the potential barrier and conversely no particle impinging on the nucleus, with less than this maximum energy, should be able to penetrate. Both of these predictions are contrary to experimental fact.

Wave theory on the other hand indicates that there is a finite probability for a particle of any energy to "leak" through the barrier, that energy levels must exist within the nucleus, and that the chance of a particle escaping from the nucleus is greatest for high energy particles. It is thus successful in accounting for the principal features of radioactive decay and the penetration of the nucleus by fast particles.

The theory also predicts, however, that if the energy of one of the impinging alpha-particles coincides with that of one of the energy levels within the nucleus—a case of resonance—then the probability of penetration approaches unity. This is a new effect and a number of experiments have been carried out to test the prediction but so far with contradictory results. Pose, for instance, using a Hoffmann electrometer found strong distinct groups of disintegration protons and a sharp resonance effect, while Stendel using a point counter found only weak groups and no resonance effect. A new attack on this problem has been made possible by the use of the recently developed FP-54 Pliotron electrometer. Recent work by Mr. Hafstad has shown that this instrument can be operated continuously at charge sensitivities as high as 80 electrons per mm. or current sensitivities of 4×10^{-20} ampere per mm. so that the usable sensitivity is limited only by the shot and thermal fluctuations which set the theoretical limit for any electrical measuring device.

With this instrument preliminary observations have given strong evidence in support of Pose's results. An absolute calculation of the yield in protons per 10^8—particles gives a result in close agreement with that of Pose and several times higher than that of Stendel. Furthermore the absorption curve shows the abrupt drops characteristic of Pose's data and contrary to that of Stendel. These results therefore indicate the reality of the resonance effect predicted by wave-mechanics. Further observations are in progress in order to determine more accurately the energies involved and to test the sharpness of resonance. (*Authors' joint abstract.*)

Discussed by Messrs. BARAFF, HAWKESWORTH, KRACEK, and BRICKWEDDE.

1053RD MEETING

The 1053rd meeting was held in the Cosmos Club Auditorium, April 8, 1933, President O. S. ADAMS presiding.

Program: R. Wiebe: *The experimental determination of some properties of gases up to 1000 atmospheres.*—A short review of some of the work done at the high pressure section of the Fixed Nitrogen Research Laboratory was presented. After giving a general description of the compression system, the deadweight gages and high pressure connections and containers, three problems were discussed briefly. The first one concerned the measurement of the concentration of water vapor in the presence of water compressed gases. It was pointed out that the true concentration cannot be calculated from Poyntings equation and reasons were given. In the discussion of the solubility of gases in liquids the interesting phenomenon of a minimum of solubility was pointed out in the case of nitrogen. Finally results on the compressibility of gases were illustrated by curves showing the behavior of hydrogen, nitrogen and methane. (*Author's abstract.*)

Discussed by Messrs. Hawkesworth and Brickwedde.

W. E. Deming: *Thermodynamic properties of real gases from compressibility data.*—Many thermodynamic properties of substances are related to the derivatives $(dv/dT)_p$, $(dv/dp)_T$, and $(d^2v/dT^2)_p$. These derivatives can be evaluated from compressibility data if the points are sufficiently numerous in the three coordinates. An equation connecting p, v, and T would, of course, give all derivatives, but so far no equation of state has been devised that represents the data for the permanent gases at pressures from 100 to 1000 atmospheres. The author has therefore resorted to graphical methods.

The chief refinement in graphical methods of determining derivatives is in the choice of function to be plotted. By selecting suitable correction functions, the smoothing of the original data and the determination of derivatives can be effected. $\Delta = v(pv/RT-1)$ and $\alpha = v(RT/pv-1)$ are examples of such functions. Graphs of Δ and α against density in families of isotherms or isobars, and against T^{-1} in isobars, have been used for the gases nitrogen, carbon monoxide, and hydrogen. In some cases, other functions of p, v, and T are more suitable as abscissas. The object is to find functions involving Δ and α that make some curves of the family as nearly linear as possible. It is a simple problem in calculus to find the relations existing between the derivatives of the plotted curves.

The actual determination of the slopes of the Δ and α curves can be effected with a straight edge laid tangent to the curve, or by some optical arrangement devised for the purpose; or the curves may also be fitted with analytical functions if desired. Since these slopes enter as correction terms to the values that the derivatives $(dv/dT)_p$, $(dv/dp)_T$, $(d^2v/dT^2)_p$ would have if the gas were ideal, just as Δ and α are correction terms to the ideal gas law, they need be estimated with only a reasonable amount of care.

The physical properties that have been determined for nitrogen, carbon monoxide, and hydrogen are the expansion coefficients $(T/v)(dv/dT)_p$, $-(p/v)(dv/dp)_T$, fugacity, heat capacities C_p and C_v, the Joule-Thomson coefficient and the change in entropy with pressure. All but the last named have been published in the Physical Review **37**: 638–654. 1931; **38**: 2245–2264. 1931; **40**: 848–859. 1932. The work on entropy will appear soon in the same journal. (*Author's abstract.*)

Discussed by Messrs. Kracek, Hawkesworth, and Brickwedde.

Informal communications were presented as follows.

P. R. Heyl.—Let n represent any number whether prime or composite and form the continued product

$$\frac{n-1}{2}\,\frac{n-2}{3}\cdots\frac{1}{n}$$

If n is prime, the successive stages of this continued product will all be whole numbers until the last stage is reached, involving division by n.

If n is composite, the integral character of the continued product will suffer a momentary halt wherever the denominator is or contains a factor of n. (*Author's abstract.*)

H. L. CURTIS.—A method was described for quadrupling the angle of displacement of a balance from its equilibrium position. A light beam is reflected by a right angle prism attached to the moving beam of the balance on to a stationary mirror which reflects it back through the same prism. The angle of displacement of the emergent beam is thus four times the angle of displacement of the balance beam.

H. L. DRYDEN.—A general characteristic of the stress-strain curve of a coiled spring whose adjacent turns are in contact was reported. Small initial tensions produce no displacement. This can be explained by the existence of a compressional force in the spring exerted by the adjacent turns pressed in contact. The initial stress balances this compressional force, and with further increase in the stress the spring behaves normally.

H. F. STIMSON.—A method was described for increasing the deflection of a light beam reflected by a galvanometer. After reflection from the galvanometer mirror attached to the moving coil, the light beam is reflected back to the galvanometer mirror by a stationary mirror mounted close to the moving mirror. The change of the angle of deflection of the emergent beam is four times the change in deflection of the moving coil, thus doubling the ordinarily obtained change of deflection of the emergent beam. Other conditions being the same, the intensity of the emergent beam is nearly the same as that that would be obtained with the usual arrangement at the same linear distance from the galvanometer.

1054TH MEETING

The 1054th meeting was held in the Cosmos Club Auditorium, April 22, 1933, President O. S. ADAMS presiding.

Program: F. L. MOHLER and C. BOECKNER: *Studies of the electrical discharge in cesium vapor.*—The uniform positive column is a mixture of atomic gas with an electron gas at a very much higher temperature. The electron gas receives power from the electrical power input and dissipates power by producing ionization and radiation. These factors are evaluated and it is found that at the lowest currents nearly all the input is radiated. At high currents an important part of the power is expended on ionization and there is some power lost in other ways. The number of inelastic collisions becomes much greater than the number of quanta radiated with high currents. It is concluded that collisions of the second kind between excited atoms and electrons are nearly as frequent as inelastic collisions. Measurements of the number of excited atoms show that this number is nearly equal to that which would exist in equilibrium at a temperature equal to the electron temperature. In the elastic scattering of electrons, the scattering by ions as well as by atoms plays an important part and the effective areas for both atomic and ionic scattering are measured. (*Authors' abstract.*)

Discussed by Messrs. KRACEK, MEGGERS, and BRICKWEDDE.

WILLIAM F. MEGGERS: *Infra-red spectrum photography.*—During the last fifty years the application of photographic methods to spectrographic in-

vestigations has not only improved the quality of observations in the visible octave but has extended the range of observations more than 16 octaves to higher frequencies. The other spectral extreme (lower frequencies, infra-red) has also been under investigation for half a century. About 8 octaves have been explored with radiometric devices, but photography has not been so successful in this range. However, in its integrating action, cumulative exposure and high resolving power, the photographic has distinct advantages over the radiometric method provided that photographic emulsions can be sensitized to infra-red radiation. A method of sensitizing ordinary silver halide emulsions to longer waves was discovered by H. W. Vogel in 1873 and for many years it was common practice among spectroscopists to bathe ordinary photographic plates in dilute solutions of photo-sensitizing dyes, and thus obtain materials for recording spectra in the red and near infra-red. The best dye for imparting infra-red sensitivity was dicyanin. This dye exhibits a maximum of absorption in the red at 7000A but with long exposures, intense light sources and efficient spectrographs many spectra were photographed beyond 9000A. Last year, the Research Laboratory of the Eastman Kodak Company announced the discovery of several new sensitizing dyes, two of which are especially useful in infra-red spectrography. These have been named Mesocyanine and Xenocyanine, the former exhibits its maximum action at wave length 8600A and the latter at 9700A. Photographic plates with these sensitizers incorporated in the emulsion have been used by the spectroscopy section of the Bureau of Standards for a survey of emission spectra in the infra-red. More than 50 spectra have thus been investigated in the interval 8000–12000A, and several thousand new lines have been added to the data of photographic spectroscopy. (*Author's abstract.*)

Discussed by Messrs. HEYL, KRACEK, TUCKERMAN, and BRICKWEDDE.

1055TH MEETING

The 1055th meeting was held in the Cosmos Club Auditorium, May 6, 1933, President O. S. ADAMS presiding.

Program: R. W. GORANSON and L. H. ADAMS: *The precise measurement of birefringence especially in strained glass.*—In connection with an investigation that involved the measurement of optical path-difference and thence birefringence it became necessary to have much higher accuracy than is ordinarily attained. After a careful study of various methods it appeared that the one which best meets the requirements of precision and simplicity is a method based on an interesting property possessed by a fixed combination of (1) a polarizer, (2) the birefracting material, and (3) a quarter-wave plate, each placed in a definite orientation to the others. When plane parallel monochromatic light passes through the elements of this fixed combination in the order shown above, the emergent light is plane polarized and the azimuth is related in a simple manner to the path-difference of the specimen. Since this azimuth can be measured by means of an analyzer and graduated circle, the determination of path-difference thus reduces itself to the measurement of an angular displacement, which can be done easily and with high precision.

The method was first made applicable to a petrographic microscope for the purpose of determining the path-difference at a given spot in small specimens. Later, there was constructed a separate polarimeter in which large specimens could be conveniently measured. This instrument has given all that was expected as to ease and rapidity of taking readings, and for any

path-difference has a sensitivity about one hundred times that of the devices in common use. (*Author's abstract.*)

Discussed by Mr. TUCKERMAN.

C. S. PIGGOT: *Isotopic composition of the radio-active elements as determined by magneto-optic technique.*—With the object of improving the calculation of geologic time by eliminating the necessity of applying a correction for the thorium content of the mineral, an attempt was made to confine the calculation only to that particular uranium and its corresponding lead which the formula theoretically represents. This necessitated the detection and estimation of the isotopes of uranium and lead. Work on the problem was actively begun in 1926, and in 1927 F. W. Aston determined the three principal isotopes of ordinary lead using material (lead tetra-methyl) furnished him by the Geophysical Laboratory. These results revealed that the atomic weight of lead, 207.2, is a statistical mean of at least three isotopes, of masses 208, 206, and 207, and that possibly others exist. In 1928 Aston made similar determinations on a radioderived lead which we sent him and found the same isotopes but in a different order of abundance. Whereas the order of abundance of the isotopes of ordinary lead is 208, 206, 207, that of radioderived lead is 206, 207, 208.

We next turned our attention to uranium, but were unable to determine its isotopes, despite generous assistance from various eminent scientists, until we obtained the cooperation of Dr. Fred Allison and his magneto-optic technique.[1]

Dr. Allison and his associates determined the number and the order of abundance of the isotopes of most of the radioactive elements from atomic number 92 (uranium) back to atomic number 81 (thallium). They are: uranium 8, thorium 8, radium 4, virginium 6, alabamine 6, bismuth 14, lead 16, thallium 8.

This unexpected number of isotopes rather overwhelmed us and we found it exceedingly difficult to account for them all within the limits of established radioactive lore. However, a tentative arrangement of interrelations has been published[2] which suggests that there exist four radioactive series, each beginning with two isotopes of uranium and ending with four isotopes of lead. The consistencies in this proposed arrangement far overbalance the inconsistencies so that it is hoped that it will serve as a suggestive and useful guide for further work in this field.

This new arrangement provides satisfactory places for several inconsistencies of the older system and furnishes an explanation for many puzzling questions. Some of these are: the independence of thorium coupled with its apparent relation with uranium; the origin of the actinium series; the definite evidence for a fourth series; the variable atomic weight of lead and the possible existence of an atomic weight for lead of less than 206.

The geophysical significances are numerous. We can now determine whether a given lead is ordinary or radioderived and can detect contamination in a sample of the latter to be used for an age determination. It is now apparent that the isotopic composition of the uranium at the time a mineral sample was formed is a controlling factor in the isotopic composition of the lead which we now find in that mineral. (*Author's abstract.*)

[1] Allison, F. and Murphy, E. J. Jour. Am. Chem. Soc. **52**: 3796. 1930.

[2] Group of six papers: Physical Review **43**, Jan. 1, 1933, of which those by Bishop and by Piggot discuss these interrelations and interpretations.

Discussed by Messrs. R. Davis, Humphreys, Kracek, and Hawkesworth.

Informal communication: Frank Neumann: *Strong motion records of the Southern California Earthquake of March 10, 1933.*—The shock was recorded at 3 strong motion stations of the Coast and Geodetic Survey at which automatic accelerographs had been installed only a few months before. They were located at Long Beach and Los Angeles (2), at approximately (later studies may shift epicenter) 17, 33, and 37 miles from the epicenter. The records exhibit certain features of strong earth movements heretofore considered questionable by many seismologists. Large vertical movements and short period waves superimposed on waves of longer period are outstanding characteristics of the Long Beach record. Wave periods ranging from 0.1 seconds to 5 seconds are recorded and there is evidence of very complex ground movement, although many of the earlier and stronger movements show distinct directional features.

Although intended primarily as acceleration recorders, it is possible to make fairly good estimates of displacement from accelerograph records. The shock occurred before specially designed displacement meters were installed although that phase of the program is now nearing completion. The records represent the first of the type ever obtained in this country and give the engineer and architect the specific information needed in the proper design of structures in earthquake regions. A report is in preparation. (*Author's abstract.*)

F. G. Brickwedde, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

Science doctorates increase.—The years of depression have had a stimulating effect upon higher education, it appears from a report to *Science* by Dr. Clarence J. West and Miss Callie Hull of the National Research Council. The number of doctor's degrees granted by American universities in the sciences has steadily increased from 1,025 in 1929 to 1,343 in 1933, these investigators found. The 1,343 doctorates granted in 1933 were distributed among the sciences as follows: chemistry, 417; physics, 123; zoology, 115; psychology, 101; botany, 79; mathematics, 78; engineering, 75; geology, 66; physiology, 39; agriculture and forestry, 36; bacteriology, 36; pathology, 23; anatomy, 17; entomology, 17; genetics, 15; horticulture, 15; anthropology, 13; pharmacy and pharmacology, 13; archaeology, 10; astronomy, 10; geography, 10; public health, 10; medicine and surgery, 10; metallurgy, 9; paleontology, 6.

Death registration area now complete.—Deaths are now recorded for the first time in the whole United States. With the admission of the State of Texas to the U. S. death registration area, recently announced by Secretary of Commerce Roper, the Census Bureau is able for the first time to compute reliably the death rate for the entire nation. The cause of every death in the United States will now be a matter of record, as will also the age, sex,

occupation and nativity of the dead person. When the Census Bureau first began to gather vital statistics for the nation, in 1902, only ten states and the District of Columbia were included in the death registration area. Gradually other states have been added. But six states have been admitted only in the last six years. Texas is still not included in the area of registration of births. It is hoped that this will be attained soon, however, thus making Uncle Sam's vital statistics 100 per cent complete so far as area is concerned.

George Washington University medical school.—The lectures in the Smith-Reed-Russell series at the School of Medicine, George Washington University, have been announced for the first semester of the present academic year. Prof. George Barger, University of Edinburgh, gave the September lecture, Prof. W. W. Cort, The Johns Hopkins University, gave the October lecture, Prof. James W. Jobling, Columbia University, will give the November lecture, Prof. Howard T. Karsner, Western Reserve University, will give the December lecture, and Dr. Arthur Cramp of the American Medical Association will speak in January.

New full time appointments at the School of Medicine, George Washington University, for the coming year include the following: Edward Bright Vedder, M.D., Professor of Experimental Medicine; Juanita Thompson, M.D., Research Associate in Experimental Medicine; Hubert Scott Loring, Ph.D., Instructor in Biochemistry; William Henry Waller, Ph.D., Instructor in Anatomy; John Ralston Pate, M.D., Teaching Fellow in Anatomy.

The regular monthly Faculty Seminar in the School of Medicine, George Washington University, was given by Prof. Earl B. McKinley of the Department of Bacteriology on October 11, 1933. Dr. McKinley spoke on the "Etiology of encephalitis with particular reference to experimental work on the recent St. Louis epidemic."

Georgetown University school of medicine.—Dr. G. H. Hansmann of the University of Iowa Medical School has been appointed associate professor of pathology and Dr. Charles J. Stucky has been appointed associate professor of biochemistry. Dr. Stucky has done work at Yale and Columbia and is at the present time Research Chemist at the New York State Psychiatric Hospital; he is a specialist on Vitamin B and on nutritional anemia. Dr. Hansmann was at one time connected with the Harvard Medical School and did some important research on tularemia, Malta fever, chemistry of nephritis, citric acid metabolism and lipuria.

Dr. M. X. Sullivan and W. C. Hess reported before the meeting of the American Chemical Society in Chicago that they have discovered a correlation between arthritis and cystine deficiency in the patients' fingernails. Administration of colloidal sulfur, they stated, brought about an increase in nail cystine and also in alleviation in the symptoms.

Bureau of Fisheries.—Elmer Higgens was an official delegate at the twentieth annual meeting of the North American Council on Fishery Investigations, held at St. Andrews, N.B., on September 13 and 14. O. E. Sette and W. C. Herrington, also of the Bureau, presented reports at this meeting.

Dr. H. S. Davis presided over the sixty-third annual meeting of the American Fisheries Society at Columbus, Ohio, September 18 to 20. Bureau of Fisheries representatives who had places on the program included the following: Frank T. Bell, commissioner, Dr. Paul R. Needham, E. W. Sur-

BER, Dr. FREDERIC F. FISH, H. C. MARKUS, RUSSELL F. LORD, Dr. A. S. HAZZARD, HILARY J. DEASON, A. C. FULLER, Dr. RALPH HILE and WILLIAM R. DUDEN, and ROBERT A. NESBIT, as well as Drs. A. H. WIEBE and STILLMAN WRIGHT, lately of the Bureau.

U. S. national parks.—The national parks were extensively used as centers of study by delegates to the International Geological Congress. Park Naturalists at Grand Canyon, Yosemite, Crater Lake, Zion, and Yellowstone National Parks aided in leading the visiting groups of scientists to the main features in which they were particularly interested.

The first Junior Park Naturalist examination was conducted by the Civil Service Commission throughout the United States on October 4. The object of this examination was to establish a register of eligibles for use in filling Park Naturalist, Park Historian, and Park Ranger positions as they open up in the national parks and monuments administered by the Office of National Parks, Buildings, and Reservations.

GEORGE M. WRIGHT and BEN H. THOMPSON of the Wild Life Division of the Office of National Parks, Buildings, and Reservations, recently investigated the winter feeding grounds of the herd of elk ranging in the Rocky Mountain National Park. Conditions warrant further studies, and quadrants will be laid out and fenced in order to determine the extent to which overgrazing is occurring. The fact that much privately-owned land heretofore fenced has been purchased by the Government and the fences removed has improved greatly the grazing situation in this park.

The northern National Parks report that the coming of winter finds the game generally in good shape, with sufficient forage in sight to last until spring. There may be some shortage, however, in the northern elk herd area in Yellowstone National Park; and in the eastern part of Glacier National Park a general shortage of wild life is puzzling administrative officials. A new policy of gradually weaning the Yellowstone animals from the artificial feeding hitherto practiced, and making them more self-dependent, has been announced by Dr. HAROLD C. BRYANT. Surplus bison will be taken from the Yellowstone herd again this winter, and killed for meat to be distributed to Indians on reservations in the Northwest.

NEWS BRIEFS

The new Science Advisory Board held its second meeting in Washington during the last week in September, with Dr. KARL COMPTON, Dr. ISAIAH BOWMAN, Dr. R. A. MILLIKAN, Dr. C. K. LEITH, Dr. JOHN C. MERRIAM and GANO DUNN in attendance. Sessions were held in the building of the National Academy of Sciences and the National Research Council.

A study made by ROLLO H. BRITTEN, J. J. BLOOMFIELD and JENNIE C. GODDARD of the U. S. Public Health Service indicates that atmospheric conditions in a southern cotton mill are not deleterious to the health of the workers. There was not enough dust to be injurious, and the high temperature and humidity, though uncomfortable at all times, could not be shown to have any definite effects, as udged by a comparison of sickness rates.

The research associates of the American Dental Association stationed at the U. S. Bureau of Standards, Dr. GEORGE C. PAFFENBARGER and WM. T. SWEENEY, in cooperation with the Bureau of Standards dental research staff including AARON ISAACS and Dr. WILMER SOUDER, gave two clinics and read three papers before the Chicago Centennial Dental Congress.

A rabbit tick, *Haemaphysalis leporis-palustris*, is suggested by Dr. R. R. PARKER of the U. S. Public Health Service as a possible vector for Rocky Mountain spotted fever in its rapid spread from its originally restricted territory in the Bitterroot Valley of Montana over most of the United States. This animal does not feed on man, but may have spread the disease from rabbit to rabbit, whence it may be carried to human beings by other parasites.

The late Maj. WALTER REED, together with the other heroic pioneers of the conquest of yellow fever, were honored by a special memorial session of the American Public Health Association at its meeting in Indianapolis during the week of October 9.

Eighteen tropical storms of hurricane proportions, reported up to mid-October, established a new all-time seasonal record for this type of disturbance in American waters. The largest number hitherto reported was sixteen, in 1887.

A national conference on the welfare of children during the depression was held in Washington on October 6, under the auspices of the U. S. Children's Bureau. Among the speakers were Mrs. FRANKLIN D. ROOSEVELT, Secretary of Labor PERKINS and Relief Administrator HARRY HOPKINS.

The rubber present in goldenrod plants is found only in their leaves, LOREN G. POLHAMUS of the U. S. Department of Agriculture has determined. The best goldenrod species, from the rubber-producing point of view, is *Solidago altissima.* Its leaves showed a maximum dry-weight content of 6.34 per cent, and all samples analyzed gave a mean of 3.45 per cent.

A notable addition to the bird collection of the U. S. National Zoological Park consists of six specimens of cock-of-the-rock, *Rupicola rupicola.* They are in all stages of plumage development, from the dark juvenile stages to the full gorgeousness of their orange-vermilion maturity. Cock-of-the-rock, Director MANN states, is an exceedingly rare bird in captivity. The new specimens arrived via the lower Amazon; it is believed they originated in the lower Andes above Iquitos.

What is believed to be an early American road roller has been discovered near Cobá, in Yucatan, by an expedition of the Carnegie Institution of Washington. It was originally a stone cylinder thirteen feet long and over two feet in diameter, and was probably pushed by hand power over the famous "white roads" of Yucatan.

LEIGH B. LINT of the U. S. Forest Service and four C. C. C. men are engaged in making a map of the 150 caves, many of them of immense size, which have been discovered and explored in the Lava Beds National Monument, Modoc National Forest, Calif. Daily new caves are being discovered and water is being found in caves where none was suspected to exist.

AUSTIN H. CLARK of the U. S. National Museum spoke on "How Animals Spend the Winter" over the network of the Columbia Broadcasting System on Friday afternoon, September 22.

Statistical indications of a long-period oscillation in mean seasonal temperatures have been found by J. B. KINCER of the U. S. Weather Bureau in a study of weather records running back in some instances more than a century. They seem to give some support to "Oldest-Inhabitant" contentions that "winters aren't what they used to be when I was a boy."

A standardized procedure for examining foods suspected of harboring microörganisms causing spoilage was advocated by LAWRENCE H. JAMES of the U. S. Department of Agriculture before the meeting of the American Public Health Association at Indianapolis.

PERSONAL ITEMS

Dr. HARRY B. WARD, permanent secretary of the American Association for the Advancement of Science, arrived in Washington on Wednesday, October 11.

Dr. CHARLES L. MARLATT, who reached his seventieth birthday on September 26, retired September 30. He is succeeded as Chief of the Bureau of Entomology by LEE A. STRONG, formerly Chief of the Bureau of Plant Quarantine.

Dr. ALES HRDLICKA, of the U. S. National Museum, has been made an honorary professor of the National Museum of Mexico.

Col. H. L. GILCHRIST, Medical Corps, U. S. Army, has been elected President of the Association of Military Surgeons of the United States. Colonel GILCHRIST will retire from the Army in January, with the rank of Major-General.

Dr. WILLIAM M. MANN, director of the National Zoological Park, was present at the Chicago meeting of the American Institute of Park Executives.

Dr. E. O. ULRICH, formerly of the U. S. Geological Survey, has been elected a corresponding member of the Society of Natural History, Frankfurt.

Dr. STILLMAN WRIGHT, former limnologist of the U. S. Bureau of Fisheries, has gone to Brazil to take part in a study of fish farming possibilities in the numerous artificial lakes and reservoirs in the northeastern part of that country.

WILLIAM C. HAINES of the U. S. Weather Bureau sailed with the Byrd expedition when it left Boston on September 25. He will renew his studies of the climate of Antarctica.

Surgeon General HUGH S. CUMMING of the U. S. Public Health Service spoke on the part played by x-rays in guarding and improving public health before the meeting of the American Congress of Radiology in Chicago on September 25.

Dr. WILMER SOUDER, Chief of the Bureau of Standards Identification Laboratory, attended the recent Chicago meeting of the International Association of Chiefs of Police and read a paper on "Safe Use of Scientific Methods of Identification."

Dr. G. W. VINAL of the U. S. Bureau of Standards, attended the meeting of the Electrochemical Society in Chicago on September 8; he exhibited reproductions of Faraday's original voltameters.

The Section of Hydrology of the American Geophysical Union has reappointed F. E. MATTHES, of the U. S. Geological Survey, as Chairman of the Committee on Glaciers for a second term of three years.

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This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors before the tenth of one month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following month.

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GEOLOGY.—*Thorium minerals as age indicators.*[1] Roger C. Wells.

A mineral thought to be uraninite was found several years ago by a mineral collector, Geo. W. Gehman, of Bethlehem, Pa., in the Sherrer serpentine quarry just N.E. of Easton, Pa., which study in the U. S. Geological Survey has shown to be thorianite (Th, U)O_2.[2] Aside from its interest as the first authentic occurrence of thorianite in the United States the mineral raises some important questions as to the usefulness of thorium minerals as age indicators which I should like to discuss briefly.

Thorianite has heretofore been described only from Ceylon, Madagascar, and Siberia. It generally carries some, and the Easton specimen carries a large proportion, of uranium. Conversely many uraninites carry some thorium. As ThO_2 and UO_2 are isomorphous, thorianites and uraninites may be considered to form a series of solid solutions.

There has been a tendency to discard thorium minerals as age indicators when the figures obtained disagree with those yielded by uranium minerals. The mere fact of disagreement, however, is in itself no proof that thorium lead has been lost by leaching, as generally assumed. It would perhaps be equally fair to assume that uranium has been lost from the uranium minerals. Thorium minerals have generally been held to give too low figures for their age. R. W. Lawson thinks that they are in many places secondary minerals. Arthur Holmes[3] assumes that they are more easily altered than uranium minerals.

[1]Published by permission of the Director, U. S. Geological Survey. Presented at a symposium on the measurement of geologic time, Sections B and C of A.A.A.S., Chicago, Ill., June 21, 1933. Received September 8, 1933.

[2] Wells, R. C., Fairchild, J. G., and Ross, C. S. *Thorianite from Easton, Pa.* Amer. Journ. Sci. **26**: 45. 1933.

[3] *The age of the Earth.* National Research Council Bull. **80**: 213.

It is well known that many thorium minerals show evidences of alteration, but uranium minerals seem in general to be even more easily altered. Thorianite and monazite have been found in placer deposits, but no uranium mineral has been so found (with the single exception of brannerite, a titanate). Uraninite is generally much veined and most specimens are surrounded by various secondary alteration products. The off-hand evidence is therefore that uraninite is as easily if not more easily altered than monazite and thorianite.

Ellsworth and others have found that the most altered specimens of uraninite seem to give too high lead-uranium ratios, that is, that uranium is lost faster than lead. The excess of uranium oxide seems to protect and retain the lead. Likewise Baxter and Alter[4] report that Katanga pitchblende is traversed by numerous microscopic veins filled with yellow material soluble in dilute hydrochloric acid. The solutions that passed through these veins seem to have extracted uranium in preference to lead, for Pb/U of the yellow material is 0.144, against 0.089 for the black unaltered pitchblende. In a few instances uranium minerals and thorium minerals from the same rock give very good agreement in their age, two conspicuous instances of such agreement having been published by Fenner, viz. certain minerals from Brazil and from Connecticut, so that there can be little doubt that the fundamental mathematical factors of the calculations are essentially correct. In many cases, however, the agreement of results based on thorium and uranium is not good and the cause has usually been assigned to loss of thorium lead by leaching. Some writers even postulate a gain or loss of lead from minerals in the same district as best accords with the analytical figures.

The minerals of the Arendal district, Norway, have given special difficulty in this connection. Recent complete analyses of uranothorites (which are silicates rather than oxides) from the Arendal district by Gleditsch and Qviller,[5] with a determination of the atomic weight of the lead, offer facts for discussing this question. They found the separate percentages of uranium lead and thorium lead in the same mineral and the following ratios which should be identical after reducing thorium to its uranium equivalent:

$$\frac{\text{Radium G}}{\text{Uranium}} = 0.05656 \qquad \frac{\text{Thorium D}}{\text{Thorium}} = 0.03206$$

[4] Science, **77**: 431. 1933.
[5] Phil. Mag. **14**: 233. 1932.

The ratios also are low for the district, compared with those of uraninites. The authors conclude: "These different facts are most easily explained by accepting Professor Holmes's suggestion that thorium minerals have been subject to a leaching-out by ground waters and that this leaching has more particularly affected the thorium-lead."

Against this conclusion are the arguments cited above. It also assumes a separation of isotopes by leaching from a single mineral, something not impossible perhaps, but generally contrary to geochemical experience, as isotopic mixtures have heretofore always been found in remarkably constant proportions everywhere in nature, except when genetically related to a parent element in a mineral. Obviously an alternative to this explanation is to assume a loss of uranium by leaching, following Ellsworth.

The use of atomic weight figures in solving this problem seems reasonably sound. For example, ordinary lead from whatever source the world over gives essentially the same atomic weight, indicating an old and thorough mixing of its isotopes. The evidence for the uniformity of uranium lead and thorium lead is not so ample but, on the other hand, there is at present little evidence against such a view in the case of older minerals. The lead from carnotite, however, does not seem to be pure uranium lead. These matters are discussed in detail by Holmes in Bull. 80 of the National Research Council and cannot be fully covered in a brief paper. The principal point that I wish to make is that lead isotopes cannot be assumed to have been separated by leaching from the same mineral, and the alternative seems to be that uranium has been leached relatively to the other elements.

What is the correct age of such minerals as the Arendal uranothorites? If uranium has been removed relative to lead, as in the altered uraninites, according to Ellsworth, the correct lead-uranium ratio should be lower. A loss of lead would affect both ratios and they should both be greater, but this could not bring the uranium and the thorium ratios into agreement. It therefore seems to me reasonable to accept the lower ratios and shorter ages in at least some of the cases where there is a difference. Thus, some of the minerals in the pegmatites of the Arendal district, based on their lead-thorium ratio would be of late Paleozoic age although the rocks of the district are thought to be pre-Cambrian.

In general the origin of the pegmatites and the condition of the specimens analyzed should also be carefully studied and described. Apparently some thorites have such small percentages of lead that

they are valueless as age indicators, or else they are of very recent formation.

The changes here indicated need not for the present affect the ages of minerals back to the Paleozoic. In the Paleozoic we should consider carefully the stage of alteration of the mineral. In pre-Cambrian minerals we may well be skeptical of the very old ones which have had to undergo the effects of many varied geologic changes.

Fortunately we have some independent checks on the lead method of computing the ages of minerals. Bradley, from a study of varves is able to extrapolate a figure for the length of the Eocene which harmonizes with that deduced by the lead method, as Schuchert has pointed out. Of course this cannot be extrapolated very far, but with further study of all the different methods of estimating geologic time we may hope for better general agreement on the main features of the problem.

SUMMARY

Some reasons are given for ascribing more weight to thorium minerals as age indicators than they have heretofore received. In uranothorites, it was argued, the lead isotopes would not be separated by leaching, so that a loss of uranium would have to be postulated to bring the RaG/U and ThD/Th ratios in agreement.

BOTANY.—*Sex and accessory cell fusions in the Uredineae.*[1] C. F. Andrus,[2] Bureau of Plant Industry. (Communicated by L. L. Harter.)

INTRODUCTION

A number of contributions have been made to the study of fertilization in the Uredineae (1) (2) (3) (10) (15) since the writer (4) first published evidence that spermatium nuclei enter the tips of superficial hyphae and migrate to the haploid cells of the aecial primordia. The new contributions have chiefly corroborated the observation that spermatium nuclei enter the exposed gametophytic hyphae. The further progress of the spermatium nuclei and the process by which they eventually become paired with individual nuclei of the aecial primordium has escaped the scrutiny of these observers. Likewise, there is still lacking an adequate interpretation of those cell fusions

[1] Received August 8, 1933.

[2] Grateful acknowledgment is made to Dr. L. L. Harter, who has provided facilities for research and advised in the preparation of the manuscript.

and apparently miscellaneous nuclear migrations in the young aecium that are so commonly associated with the act of fertilization.

The writer has recently had occasion to examine a number of slides of the bean rust, *Uromyces appendiculatus* (Pers.) Fries, and the cowpea rust, *U. vignae* Barclay, some of them prepared after the earlier communication was submitted for publication. In a number of instances details of the obscure fertilization process appeared on these slides with unusual clarity and it is believed that these observations are of sufficient interest and value to deserve some record. The new observations will emphasize more strongly that the relation between spermatium and receptive cell in the aecium of Uromyces is a true sperm-egg relation, and will indicate in addition that certain cell fusions which accompany diploidization in the aecium are an important accessory to the fertilization process. In conclusion it is proposed to discuss the possible bearing of the newly observed phenomena of sex and organography in the Uredineae upon the general problem of sex in fungi.

THE ENTRANCE AND MIGRATION OF SPERMATIUM NUCLEI

Attention has been given to a more detailed examination of the means by which spermatium nuclei reach the aecium from their point of entrance at the host epidermis. A first fact worthy of comment is the apparent ease with which the nuclei disregard the numerous crosswalls in their passage through the often intricate maze of mycelial strands. This fact has been verified by the observation that the spermatium nuclei can be made to contrast strongly with the ordinary or indigenous cell nuclei of the gametophytic mycelium and thus can be identified at various points throughout the infected area. Contrast in stain has been obtained with the triple combination of safranin, gentian violet, and orange G on material fixed in Carnoy's and in Fleming's weaker solution.

When revealed by a good differentiation of stain the spermatium nuclei display a curiously compact structure which differs markedly from the structure of the indigenous cell nuclei. Figure 1, C, G, H, I, and L shows this difference in structure and indicates the difference in intensity of stain. The normal or indigenous cell nuclei show reticulation outlined in gentian violet, which is frequently very distinct in the greatly enlarged egg nuclei. A conspicuous nucleolus is invariably present in the (basal cell) nuclei and frequently is equal in diameter to the spermatium nucleus at the time the latter has just entered

the basal cell. The nucleoli retain the safranin stain, but often with a pale center giving somewhat the appearance of a vacuole. (Fig. 1, K, *c*.) Spermatium nuclei rarely show reticulation but are stained richly, with gentian violet predominating, and contrast in brilliance with the dull safranin of the egg nucleoli. An eccentric position of the deeply stained portion is a common characteristic of the spermatium nuclei at this stage. The stainable portion is frequently crescent-shaped (fig. 1, J, L) or comma-shaped (fig. 2, C, D); a faint edging or halo (fig. 2, F, *b*) often gives them a curiously detached appearance. The distinctive appearance of the spermatium nuclei is lost during the first conjugate division with egg nuclei.

Having observed the characteristic structure and staining properties of the newly introduced spermatium nuclei, it is possible to observe these bodies in their devious progress through the crosswalls of the trichogenous hyphae and in the act of migrating between adjacent cells of the fertile layer in the aecium. Figure 1, A and B, shows fusion of spermatia with the tips of superficial hyphae. Figure 1, D to F, shows spermatium nuclei in process of migration through hyphal crosswalls. Many such cases have been observed. In Figure 1, G, is shown a spermatium nucleus as it maneuvers past the cell nucleus in its passage through the trichogenous hypha. Spermatium nuclei after they have reached the base of the aecium are shown in Figures 1 and 2. Figures 1, J, K, and 2, A, show migration between continuous and between adjacent cells at the base of the aecium. On certain slides these can be seen with great frequency.

It is necessary to conclude that cell walls furnish remarkably little inconvenience to the movements of nuclei. Whether passage through the walls is secured by dissolution, or by openings normally present, or whether the forces causing the movements of the nuclei are sufficiently potent to cause mechanical rupture, is not entirely apparent from the observations made. From the appearance of the crosswall after passage of the nucleus shown at *e* in Figure 2, I, it would seem

Fig. 1.—Entrance and migration of spermatium nuclei of *Uromyces appendiculatus*, A, E to G, J to M, and *U. vignae*, B to D, H, I. ×1500. A, B.—Fusion of spermatia with gametophytic hyphae. C.—Spermatium nucleus (*a*) contrasted with cell nucleus (*b*). D to F.—Migration of spermatium nuclei (*a*) through crosswalls of trichogenous hyphae; cell nuclei at *b*. G.—Indigenous cell nucleus (*a*) in a conducting hypha allowing a spermatium nucleus (*b*) to maneuver past on its way to the aecium. H.—Contrast of spermatium (*a*) and cell nucleus (*b*). I.—Initial fertilization of a basal cell; spermatium nucleus at *a* and egg nucleus at *b*. J.—Entrance of spermatium nuclei (*a*, *b*, *c*) into basal cells. K.—Entrance of spermatium nuclei (*a*, *b*) into basal cells; the egg nucleolus (*c*) is often similar in size to spermatium nuclei but differs markedly in stain. L.—Early relation of egg (*a*) and spermatium (*b*) nuclei. Note orientation of the egg nucleus as compared to I. M.—Entrance of spermatium nuclei (*a*, *b*) into basal cells. The normal cell nucleus is shown at *c*.

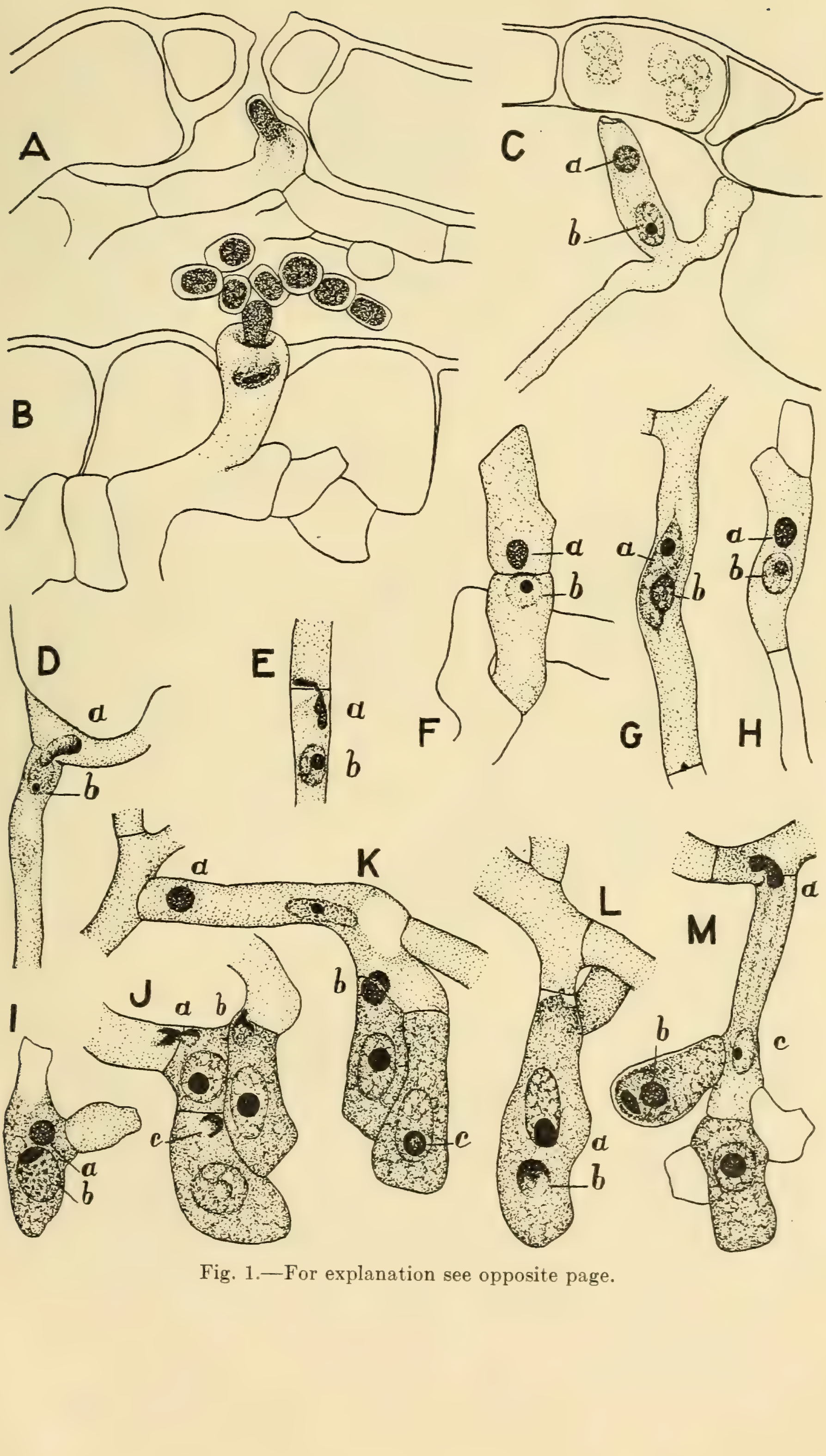

Fig. 1.—For explanation see opposite page.

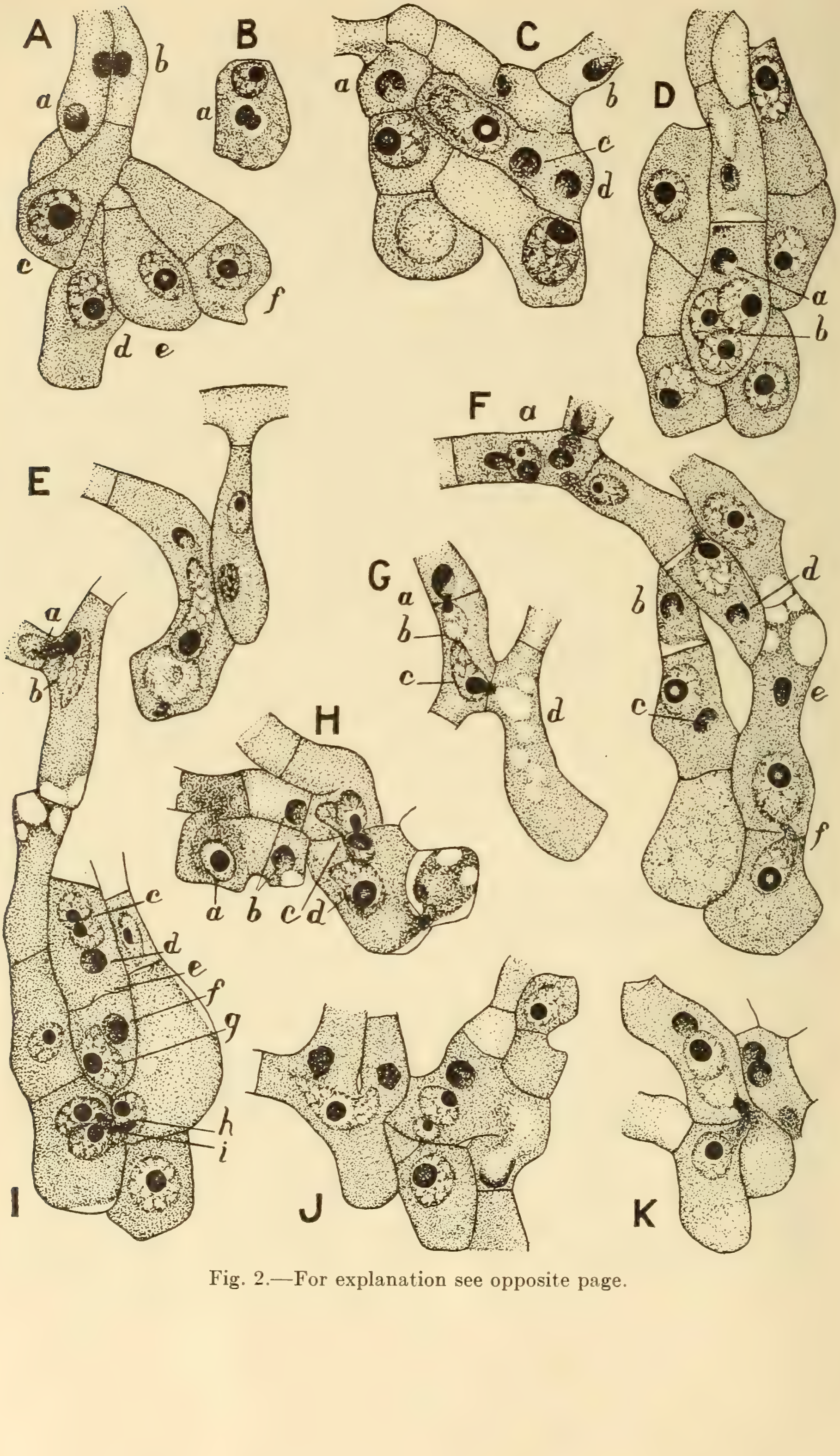

Fig. 2.—For explanation see opposite page.

that the wall has been forcibly ruptured,—less probably dissolved. In Figure 1, M, the nucleus (*a*) is not enough constricted to suggest that its passage is restricted to a small pore. However, Figure 1, E, shows a nucleus much constricted in its passage through the cross-wall. Furthermore, it is clear that a pore is commonly present in these hyphal crosswalls, even though it is not certain that the presence of a pore facilitates migration of the nuclei.

It is apparent from the evidence just presented that spermatium nuclei migrate through gametophytic hyphae from the epidermis to the aecium, and these conducting hyphae are still gametophytic after passage of the spermatium nuclei. Up to this point, therefore, the process of fertilization offers little suggestion of any relationship to the diploidization process supposed by Buller (8) to occur in Hymenomycetes.

Allen (1) suggested that in some species of *Puccinia* the aecium may be diploidized by the growth into the aecium of sporophytic hyphae originating near the point of entrance of spermatium nuclei. She even thought she saw some evidence of this on her slides of *P. triticina* Eriks. and *P. coronata* Cda. (2). Such a procedure is conceivable and even probable for such species as *P. caricis* (Schum.) Rebent. where cells of the hymenium are observed to be diploid from their origin (13), but there is no indication that such a method of diploidization may occur even rarely in the bean and cowpea rusts. Aggregations of well differentiated haploid cells are present in definite localized regions of the thallus, and fertilization of these cells is initiated by the entrance of spermatium nuclei. There is no reason to conclude that this is not as true a sperm-egg relation as is to be found in any group of Thallophytes.

ACCESSORY CELL FUSIONS IN THE AECIUM

A further study has been made of the cell fusions and nuclear migra-

Fig. 2.—Nuclear relations in the aecium of *Uromyces appendiculatus*, A, C to K, and *U. vignae*, B. ×1500. A.—Entrance of spermatium nuclei (*a*, *b*) at base of aecium; egg or basal cell nuclei are shown at *c* to *f*. B.—Possible division or fragmentation of a spermatium nucleus (*a*) after it has entered a basal cell. C.—Spermatium nuclei (*a* to *d*) showing evidence of division and migration. D.—Spermatium nucleus (*a*) in a basal cell with 3 egg nuclei (*b*). E.—Migration of an egg nucleus toward an approaching spermatium nucleus. F.—Migration of spermatium nuclei through a series of conducting cells. Note migration of the egg nucleus (*f*) from the terminal cell of the series. A normal cell nucleus is shown at *a* with several spermatium nuclei; spermatium nuclei also at *b* to *d*. G.—Spermatium nucleus (*a*) approached by a normal cell nucleus (*b*) and an egg nucleus (*c*) which has vacated the basal cell (*d*). H.—Nuclear migration at base of aecium; egg nuclei at *a*, *c*, *d*, and spermatium nuclei at *b*. I.—Migration of both spermatium and egg nuclei; spermatium nuclei at *a*, *d*, *f*, and probably *i*; egg nuclei at *b*, *g*, *h*; *c* is probably a recently divided egg nucleus; note ruptured crosswall at *e*. J, K.—Migration of egg nuclei after entrance of spermatium nuclei.

tions that occur within the aecium immediately following the first stage of fertilization. It appears that the fertilization process does not cease with the entrance of a particular spermatium nucleus into a particular egg cell; there occur divisions of the egg nuclei and probably also of the spermatium nuclei, which are followed by further migrations of both spermatium and egg nuclei. As a result numerous originally uninucleate cells are diploidized following entrance of only a few spermatium nuclei. Some suggestion of this was made in an earlier publication (4). It is believed to be possible that in the accessory cell fusions and nuclear migrations there may be found a process in some degree comparable to the diploidization in Hymenomycetes.

It is necessary to distinguish at least two types of cell fusion in the aecia of *Uromyces*, fusions that are undoubtedly stimulated by the entrance of spermatium nuclei, and fusions that occur in aged sterile aecia showing evidence of degeneration. Fusions of the second type, in their advanced stages, involve an almost general dissolution of cell walls accompanied by a multiplicity of small nuclei, often inadequately stained. Allen (2) illustrates fusions of this type for *Puccinia coronata*. They occur regularly in unfertilized infections of bean rust. Migrations of nuclei through small openings are characteristically absent from such material. Initial stages in degeneration of sterile aecia may show fusions that are not clearly distinguishable from fusions that accompany fertilization. It may be stated generally, however, that cell fusions in a sterile aecium involve a general disorganization of cell partitions, whereas fusions associated with fertilization involve nuclear migrations with only local dissolution or rupture of cell walls.

The explanation of cell fusions associated with fertilization in bean and cowpea rusts is then largely a problem of interpreting the nuclear migrations that accompany or follow entrance of spermatium nuclei into the aecium. It appears that the nuclear migrations involve movements of both spermatium and egg nuclei. The difficulty in deciding this point is increased by the fact that spermatium nuclei no longer show the characteristic structure and stain after the first conjugate division. Consequently many of the migrating nuclei which appear to have the structure of an egg nucleus may in fact be of spermatial origin.

Material fixed at an early stage in fertilization will frequently show basal cells with a very nearly ideal relation of egg and spermatium nuclei. Such a one is shown in Figure 1, I. So far as could be determined this is the first spermatium nucleus to enter this aecium. The

figure is drawn from a 16 day infection fixed very soon after spermatia were transferred on the surface of the host leaf. The figure certainly suggests a typical sperm-egg relationship, comparable, for example, to the fertilization of an egg in the archegonium of a fern. Figure 1, L, is only a little less convincing in this respect. Of possible significance is the apparent shift in position of the egg nucleolus, which in this case corresponds to the relative position of the spermatium nucleus in the two figures. Fertilization, however, is not ordinarily so simple as would be indicated by these two figures. There is evidence that the spermatium nuclei may divide soon after entering the first basal cell, as appears to be the case in Figure 2, B. The division, if it is such, would appear to be amitotic. Figure 2, A (*b*), may represent such a division occurring at the cell partition. Also the two distinct spermatium nuclei (*c*, *d*) represented in Figure 2, C, may have entered separately but quite as probably are the result of a nuclear division.

The egg nucleus also appears frequently to undergo division, just preceding or immediately following entrance of the spermatium nucleus. That the first divisions of spermatium and egg nuclei are not simultaneous is evidenced by Figure 2, B, as well as *a* and *f* of Figure 3, A. The migration into an adjacent basal cell of one portion of a recently divided spermatium nucleus is suggested in Figure 2, I, although again it should be stated that the spermatium nuclei shown (*d* and *f*) may be of separate origin. That egg nuclei also migrate from cell to cell during this period is evidenced in Figures 2 and 3.

The presence of 2, 3, and occasionally 4, egg nuclei in a single basal cell is a common observation at an early stage in fertilization. The explanation would appear to be that the approach of spermatium nuclei is a stimulus that promotes movement of egg nuclei. This is suggested in Figure 2, G, where the egg nucleus (*c*) has completely vacated the basal cell (*d*) and entered the conducting hypha where the smaller cell nucleus (*b*) already appears to be assisting the approaching spermatium nucleus (*a*) through the narrow aperture in the crosswall. Also in Figure 2, F, where the approach of several spermatium nuclei appears to have exerted some force upon the nucleus in the most terminal unfertilized cell. Again in Figure 2, E, and H to K, and Figure 3, A, migrations of egg nuclei are occurring at several points, but usually in a direction toward spermatium nuclei. Curiously the 2 egg nuclei in Figure 3, B, appear undecided which way to move. Not all instances of this sort lend themselves to interpretation.

The movement of egg nuclei toward the approaching spermatium nuclei may be due to a definite attraction between the two kinds of bodies or it may be merely incidental to a general cytoplasmic movement which has the effect of concentrating the active protoplasmic substances in the fertile layer of the aecium. A general cytoplasmic movement toward the fertile layer would result in the withdrawal of nutritive materials from the sterile portion of the aecium and likewise

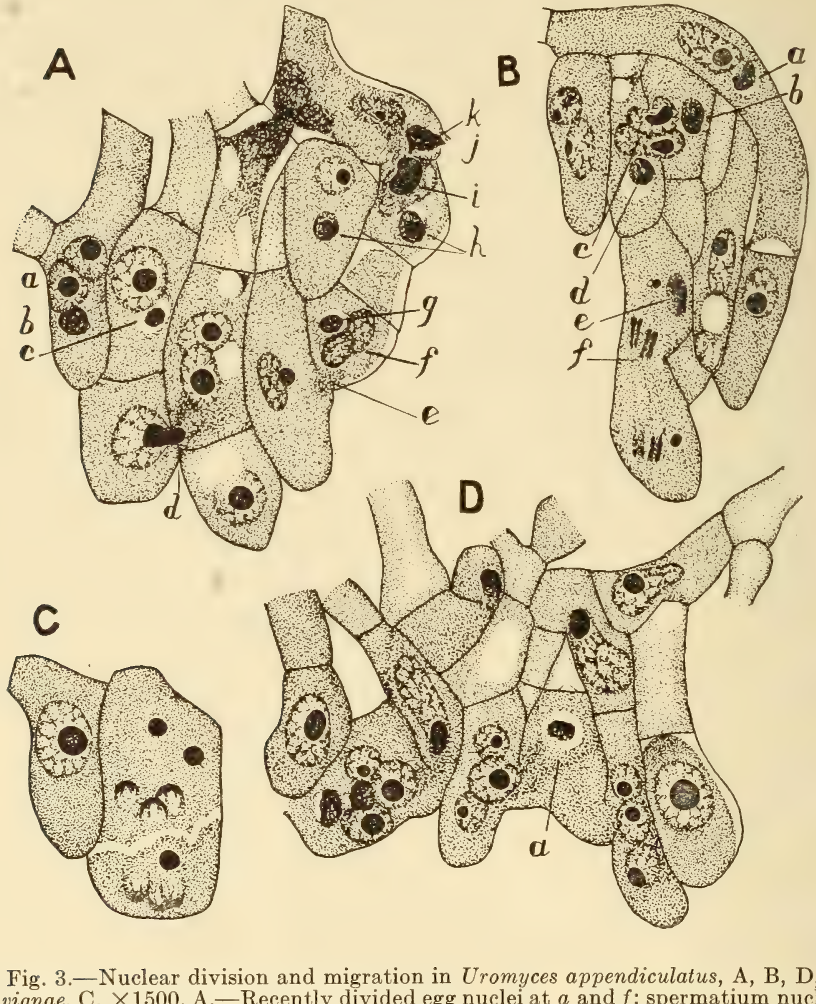

Fig. 3.—Nuclear division and migration in *Uromyces appendiculatus*, A, B, D, and *U. vignae*, C. ×1500. A.—Recently divided egg nuclei at *a* and *f*; spermatium nuclei at *b, c, g, h*, and *k*; cell fusions at *d, e*, and *j*; egg nucleolus at *i*; migration at *d* may involve either a spermatium or an egg nucleus. B.—Migration of egg nuclei at *c*; spermatium nuclei shown at *a, b, d*, and *e*; the conjugate division at *f* probably involves only egg nuclei. C.—Division of a trinucleate basal cell. D.—Cell fusions with evidence of nuclear migrations at several points. An adjacent section shows an egg nucleus and a second spermatium nucleus in the cell at *a*.

might conceivably draw spermatium nuclei from the peripheral hyphae toward the aecium. Whatever may be the force causing migration of egg nuclei from an unfertilized cell into a fertilized cell, such migration would appear to have a nutritive effect and would support later proliferation of the multinucleate basal cell. The cell fusions and nuclear migrations observed in the aecium of *Uromyces* obviously correspond to those described by Blackman (6) and Christman (9) for numerous species of Uredineae; and, although they are not gametic fusions in the sense proposed by the above authors, they do appear to be an important and perhaps characteristic accompaniment of the sexual act.

Migration of egg nuclei is frequently from an unfertilized cell into a cell which has just received or is about to receive a spermatium nucleus. This in certain instances accounts for the multinucleate condition of newly fertilized cells. (Fig. 2, D, I, and K.) In other instances (fig. 3, A and D) the multinuclear condition is probably the result of nuclear divisions that occur previous to the familiar conjugate divisions. Upon this basis it cannot always be inferred that two nuclei in a binucleate basal cell are necessarily of separate origin or of different sex. It is probable that the conjugate division shown in Figure 2, B, involves nuclei neither one of which is of spermatial origin. Later divisions of this basal cell would probably involve the spermatium nucleus shown at *e*.

Some observations have been made concerning the fate of the excess nuclei after spore formation is begun. Reduction to the single pair of nuclei that is so characteristic in cells of a mature aecium may be accomplished by any one of four methods. 1. By eliminating the extra nuclei in the first spore abstricted. 2. By migration of extra nuclei into adjacent unfertilized cells. 3. By degeneration of one or more nuclei. 4. By proliferation of the basal cell into two or more spore chains. There is evidence that all four methods are actually followed at various times. Frequently, as in Figure 3, C, a few basal cells continue to produce spores with more than two nuclei.

It is evident from the above that great irregularity characterizes the nuclear behavior in a fertilized rust aecium. The apparently miscellaneous nuclear divisions and migrations have the result, however, of securing the diploidization of numerous basal cells by means of a comparatively few spermatium nuclei. In this procedure there is some suggestion of the diploidization process in Hymenomycetes, where it is supposed (8) that a single nucleus of one sex can diploidize a whole thallus of different sex. In respect to the two species of *Uromyces* here

concerned, it would be a mistake to suppose that the whole rust thallus is comparable to the thallus of a Hymenomycete. For here, at least, the whole thallus is not diploidized by the spermatium nuclei, but only definitely differentiated gametic areas of the thallus. Surrounding hyphae serve as conducting channels for spermatium nuclei but remain haploid after passage of the nuclei.

DISCUSSION

The present communication emphasizes the earlier observation (4) that fertilization of a haploid aecium by entrance of spermatium nuclei in *Uromyces* constitutes a true sperm-egg relation. It can scarcely be denied that each gametophyte of *Uromyces* produces organs that not only function as gametes but have some of the morphological peculiarities of the sperm and egg mechanisms of certain more familiar plants. It would be unwise, however, to emphasize any apparent homologies with the sperm-egg mechanisms of any other group of organisms.

Some confusion has resulted from the paradox offered by fungi of this type, wherein a full complement of "sex" organs are present on individuals of both "sexes." A comparable situation has long been familiar to students of flowering plants; but botanists have never looked upon non-compatibility groups of flowering plants as being sexual groups. Sperm and egg mechanisms, as conceived by the writer, are a part of the characteristic organography of particular species and are frequently independent of the physiological condition of individuals in respect to compatibility. This viewpoint seems to be demanded by the newly observed facts of sex segregation and organography in fungi. Many species that would be homothallic in respect to sex organs are in fact heterothallic in respect to sexual compatibility. Furthermore, it is probable that in certain species that appear to be typically homothallic (and self-fertile) the development of fruiting bodies may proceed parthenogenetically or without any reaction between the sperm and egg mechanisms present (5). Such a homothallic species is in fact unisexual.

Dodge (11) has explained in considerable detail how the sexes segregate in the ascus of *Neurospora* so as to form unisexual strains (of heterothallic forms) and bisexual strains (of homothallic forms). He presumes that a unisexual strain consists of individuals that correspond to either sperm-producers or egg-producers, while the bisexual strain consists of individuals that produce both sperm and egg mechanisms. In the case of certain rust fungi and Ascomycetes,

mycologists are forced to an embarrassing conclusion, for here the "sexes" (organs) are obviously segregated in the vegetative divisions of the gametophyte while the conditions of maleness and femaleness (the factors for copulability) are segregated in the nuclear divisions in the ascus and in the basidium. Which of the two above relations is actually segregated in the ascus of *Neurospora*? More recent observations on this fungus (12) would seem to indicate that copulability factors are segregated in the ascus and that the strains which, according to Dodge (11), are unisexual are in fact producers of both sperm and egg mechanisms. Uredineae of the *Uromyces* type are similar to *Neurospora* in that respect.

There is some inclination to look upon sex phenomena in the Uredineae as comparable in many respects with the diploidization process in Hymenomycetes as postulated by Buller (8). Undoubtedly there are points of similarity. Buller indicates how, "in a very simple way," a diploid cell can fertilize a haploid cell, and how the diploidization may continue progressively so that a whole haploid mycelium may be diploidized,—presumably by the entrance into one haploid cell of a single nucleus of opposite sex. There is no evidence from Buller's researches that fertilization by a diploid mycelium is not preceded by a type of reduction. Vandendries and Martens (16) have shown that haploid oidia are formed by diploid mycelia of *Pholiota aurivilla* Batsch, and it is conceivable that this may be a common procedure in other Hymenomycetes. Likewise, Brown (7) presents no evidence that haploid cells are not formed by the rust sporophyte immediately preceding fertilization of a gametophytic mycelium of *Puccinia helianthi* Schw. These announcements show the inadequacy of methods of research in this field which do not include a study of cytological phenomena.

On the other hand, there is perhaps nothing remarkable in the fact that a diploid (or binucleate) cell can fertilize a haploid cell, or that fertilization can occur in any combination whatsoever, providing the necessary sexual gradient exists between the nuclei concerned. On the preceding pages there is described what is believed to be such a process taking place in the aecium of *Uromyces*. By means of nuclear division and migration a single spermatium nucleus is sufficient to fertilize numerous basal cells. Diploidization in *Uromyces*, however, is restricted to specially differentiated gametic areas. In this respect, and in other details, it contrasts strongly with the scheme of diploidization outlined by Buller (8), which apparently is based largely upon the cytological work of Lehfeldt (14).

Buller (8) has attempted to draw a fundamental distinction between the processes of fertilization in Hymenomycetes and in higher plants. The cells which become diploid in Hymenomycetes are not egg cells, Buller conceives, for the whole haploid mycelium should be looked upon as a multicellular egg. Likewise, according to this author, the haploid cells (oidia) which frequently initiate fertilization are not sperm cells, for they too are capable of independent growth and of forming a multicellular individual. This is an ingenious theory. At the same time it might as easily be conceived that the fern gametophyte is a multicellular egg, but upon this multicellular individual there are usually developed characteristic structures which bear the relation of sperm and egg mechanisms. This is quite as true of the rust gametophyte. In the fern gametophyte as well as in the fungus gametophyte fertilizations are not restricted to these differentiated structures.

Sperm and egg mechanisms in all their variations may be looked upon as a part of the characteristic organography of particular species. They may be no more male and female than any two other organs of the individual. In many of these species they are a means by which alone diploidization is possible. In other species the cellular anatomy may be such that sexual unions are not restricted to any specially differentiated cells, even though such be present and functional. The new observations on sex in fungi have revealed little concerning the nature of sex, but they have brought into question the arguments of those who seek to place in different categories gametic unions occurring between undifferentiated cells and those occurring between cells differentiated as sperm and egg. Apparently both types of fertilization occur in the rust fungi.

SUMMARY

Continued observations on fertilization in two species of *Uromyces* emphasize the view that the relation between spermatium and haploid basal cell is a true sperm-egg relation.

The structure and staining properties of migrating spermatium nuclei are described and contrasted with those of nuclei in the conducting strands and in basal cells of the aecium. By means of this contrast it is possible to identify spermatium nuclei at various points within the gametophyte thallus.

The fusion of spermatia with superficial hyphae and the passage of the spermatium nuclei through the conducting strands is described in some detail. The trichogenous hyphae remain haploid after passage of the spermatium nuclei.

Cell fusions that occur in sterile (unfertilized) aecia are distinguished from those occurring at the time of fertilization. Fusions of the first type involve a general disorganization of cell partitions while fusions of the second type are incidental to nuclear migration with only local dissolution or rupture of cell walls.

The period of fertilization is accompanied by migrations of both spermatium and egg nuclei, both of which are believed to divide independently during the initial stage. Migration of egg (basal cell) nuclei appears to be related to the approach of spermatium nuclei. A number of significant details in the relations of spermatium and egg nuclei are described.

The nuclear migrations in the aecium are believed to represent a process of diploidization that may be remotely comparable to diploidization in Hymenomycetes.

The discussion covers the possible bearing of sex phenomena in the Uredineae upon the larger problem of sex in Thallophytes.

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BOTANY.—*A new* Gossypium *of Lower California.*[1] THOMAS H. KEARNEY, Bureau of Plant Industry.

In 1931, as guests of Mr. Allison V. Armour, G. N. Collins, J. H. Kempton and the writer participated in a cruise in the Gulf of California. Seeds of *gossypium harknessii* Brandegee were collected on Carmen Island and, of what was supposed at the time to be a peculiar form of the same species, on San Marcos Island. Through the courtesy of Mr. and Mrs. E. H. Page, resident on the latter island, an abundant supply of seeds was received later. Plants were grown in California from these several lots of seed; and it became apparent, almost immediately, that the San Marcos Island plant is very different from typical *harknessii*, as represented by the Carmen Island collection.[2] Plants of both forms flowered and fruited at several stations in southern California in 1933. Comparison of these living plants, growing side by side, left no room for doubt that the plant of San Marcos Island is a quite distinct species. It has not, apparently, been described previously, although herbarium specimens were collected at the same locality by Ivan M. Johnston, as a member of the expedition of the California Academy of Sciences to the Gulf of California in 1921.

It is a pleasure to name this attractive little shrub in honor of Mr. Allison V. Armour, whose generous cooperation has enabled the Department of Agriculture to introduce valuable plants from many parts of the world, and who made it possible to obtain the evidence that the San Marcos Island plant is a new species of *Gossypium.*

Gossypium armourianum, sp. nov.

Frutex ramosissimus, ramis patulis vel adscendentibus, praeter corollam, capsulae partem interiorem, et semina mox glaberrimus; lamina folii crassa, nitida, 2–3.5 cm. longa et subaequilata vel latior, non lobata, subcordata, apice obtusa vel acutiuscula et saepe mucronata; pedunculus anthesi 2–4 cm. longus, subclavatus, sine nectariis; involucellum caducissimum, bracteolis 2–5 mm. longis distinctis subulatis integris; calyx 5-dentatus, dentibus 1–2 mm. longis, triangulis vel subulatis; petala 2.5–4.5 cm. longa, sulfurea, maculam conspicuam rubram ferentia vel nonnunquam immaculosa; filamenta 2–4 mm. longa, tenua; antherae ca. 1 mm. longae; styli et stigmata 20–25 mm. longa; ovarium 3–4-loculatum, loculis plerumque 3-ovulatis; capsula 10–20 mm. longa, ovoidea, abrupte acuminata vel interdum solum apiculata, intus margine valvarum glabra vel pilis raris longis debilibus ciliata; semina loculo quoque 1–3, 7–9 mm. longa, saepe solide connata, obovoidea, angulata, pilis appressis crispatis subfulvis dense pilosa.

[1] Received November 11, 1933.

[2] The difference was noticed, in the early seedling stage, by C. G. Marshall, Superintendent of the U. S. Acclimatization Garden, Torrey Pines, Calif.

Characters not stated in the preceding diagnosis are as follows: Shrub compact, broader than high, with the main stem or leading branch attaining a length of 115 cm. and a diameter at base of 2.5 cm., obscurely granular-puberulent on the very young parts, including the caducous stipules and involucel, dotted with slightly prominent, brown (drying black) oil glands on the twigs, stipules, petiole, midvein of leaf dorsally near base, peduncle, involucel, calyx, petals, column, exserted portion of pistil and capsule; twigs reddish and more or less glaucous, older bark reddish-brown; stipules 1.5 to 2.5 mm. long, subulate, soon deciduous; petiole slender, as long as or slightly longer than the blade, usually dark red toward apex; leaf blades dark green, with a very small greenish or brownish pulvinus, punctate with imbedded, dark brown oil glands, rounded-deltoid, often 1.5 times as wide as long, crenulate, the basal sinus open and broadly triangular, palmately 5-veined, with a small deltoid or lanceolate nectary near the base of the midvein, dorsally; flowers borne (usually singly and often as if terminally) on very short, spreading or ascending branchlets, to which the peduncle is articulated; involucel caducous long before anthesis, usually when the flower bud is not more than 6 mm. long; calyx 5–10 mm. high at anthesis, copiously dotted with oil glands; petals at apex about as wide as long, with upper margin slightly erose, often puberulent (and reddish) on the dorsal surface where exposed in bud, ciliolate above, ciliate towards base, densely so on the very short claws with hairs 1–2 mm. long, pale green-yellow,[3] the subbasal spot, when present, 5–10 mm. long, solid or striate, carmine; column staminiferous one-third to two-thirds of its length; stamens with pale orange anthers, the enlarged summit of the filament carmine, pollen orange-yellow; pistil with the exserted portion usually longer than the column and conspicuously dotted with reddish brown oil glands; stigmas erect, closely connate; capsule usually sharply acuminate with the point 1 to 5 mm. long, pale green before maturity, conspicuously dotted with oil glands much larger than those of the calyx; seeds rather narrowly obovoid, rounded-convex on the back, usually flat on the inner face or faces, coffee-colored, the hairs pale brown and attaining a length of about 4 mm.

Type Locality: San Marcos Island, near the eastern coast of Lower California, latitude 27° 15′N. Type in the U. S. National Herbarium, no. 1,184,705, collected by T. H. Kearney, August 25, 1933, at Palm Springs, California, from a plant grown from seeds from San Marcos Island.

Geographical Distribution: Known only from the type locality.

Specimens Examined: San Marcos Island, *Johnston* 3645; *Collins, Kearney & Kempton* 251. Also living plants in the U. S. Department of Agriculture collections at Riverside, Palm Springs, and Bard, California, and Sacaton, Arizona, grown from seeds from San Marcos Island (F.P.I. 92903, 93543, 95656).[4]

This species is unique in having a very small involucel, that disappears long before anthesis. It is most nearly related to *G. harknessii* Brandegee, which differs from *G. armourianum* as follows: Stem or leading branch longer and thicker (attaining a length of 165 cm. and a diameter at base of 6.5 cm.); branches fewer, longer, less intricate, and more nearly erect; twigs

[3] Ridgway, Robert. *Color standards and color nomenclature.* Washington, 1912, Plate V.

[4] The corresponding C. B. (Cotton Breeding) numbers under which seeds were distributed by the Department of Agriculture are, 862, 867, 930.

less colored, these and the petioles densely stellate-puberulent; stipules longer (3 to 6 mm. long); leaf blades thinner, lighter green, not shiny, at least twice as large, distinctly 3-lobed, usually 7-veined from the base, deeply cordate at base with the sinus usually narrow and often closed above, acutish to short-acuminate at apex; peduncle much shorter (5 to 12 mm. long); involucel more persistent (usually until anthesis), the bractlets much larger (10 to 25 mm. long and 7 to 15 mm. wide), ovate or oblong-ovate, entire, denticulate or often rather deeply few-dentate toward apex; calyx merely undulate or denticulate on the margin and sparsely gland-dotted; capsule broader (often nearly spherical in shape), with inner margins of valves copiously long-ciliate; seeds plumper, the hairs longer, silvery-gray in color.[5]

Another interesting difference is in the oil of the walls of the unripe capsules. This is bright orange in both species, but has merely a peppery odor in *G. harknessii* (as in the cultivated Egyptian cottons), whereas in *G. armourianum* the oil is fragrant, with an odor suggesting that of rose geranium (*Pelargonium graveolens*).

G. armourianum is known only from San Marcos Island, where, as indicated on the labels of Johnston's specimens, it is "very common in draws, on talus and in sandy bottoms." When the writer saw the plants there on April 6, 1931, they were flowering profusely and had many unripe capsules, although there had been no heavy rainfall at that locality for more than 18 months. This species is, therefore, pronouncedly xerophytic like *G. harknessii*, which occurs in similar habitats.

The type collection of *G. harknessii* was made by T. S. Brandegee in 1889 on Santa Margarita Island, off the west coast of Lower California, at approximately latitude 24° 30′ N. This species has been collected also at several localities on the east coast of the peninsula and neighboring islands, from somewhat north to somewhat south of latitude 26°. Plants grown in California from seeds collected on Carmen Island by Collins, Kearney, and Kempton, are very similar to the type specimen in the herbarium of the University of California.

[5] As the two genera are defined by Bentham and Hooker (Genera Plantarum), by Schumann (Engler und Prantl. Natürl. Planzenfam.), and by Ulbrich (in Bot. Jahrb. 50 (Suppl.): 360, 1914), *armourianum* belongs to *Cienfugosia* rather than to *Gossypium*, because of its caducous involucel of small, narrow bractlets. But in *G. harknessii* the bractlets are much larger and less caducous and in *G. davidsonii* Kellogg they are both large and persistent. The three species are so evidently related to one another and are so like *Gossypium* in other characters that reference of any of them to *Cienfugosia* would be an unsatisfactory solution.

ZOOLOGY.—*Descriptions of five new species of seahorses.*[1]

Isaac Ginsburg, U. S. Bureau of Fisheries. (Communicated by Waldo L. Schmitt.)

An attempt to elaborate satisfactory characters by which to distin-

[1] Published by permission of the U. S. Commissioner of Fisheries. Received August 9, 1933.

guish properly the American species of *Hippocampus* and their close relatives on the eastern Atlantic coast led to the surprising discovery that the following five species have remained unnamed to this late date. In view of the chaotic state in which the taxonomy of *Hippocampus* was found to be during the course of this study, a revisionary account of the species inhabiting these waters has been prepared and will be published at a later date.

Hippocampus europaeus, new species

Description of type specimen: Brood pouch well developed. Trunk segments 11. Caudal segments 39. Dorsal rays 18. Pectoral rays 14. Coronet of medium height, rather broad. Tubercles of medium development, not markedly obtuse. Length 95 mm.; depth 15.8; head 19.7; snout 6.4; eye 4.2; postorbital part of head 10.1; trunk 29.7; and tail 65.2 per cent of length.
Holotype: U.S.N.M. Cat. No. 28544; La Rochelle, France.

Discussion: It seems strange, indeed, that what appears to be a common seahorse on the Atlantic coast of France and possibly other parts of Europe, should prove to be a new species. However, a study of the European material available to me, although not extensive nor in the best of condition, admits no other interpretation. The seahorses from the Atlantic coast of Europe were heretofore identified with either one or the other of the two common Mediterranean species. As compared with those species, it differs from *H. guttulatus* Cuvier in having a markedly shorter snout, there being no intergradation in the material examined, and in having less numerous dorsal and pectoral rays, these latter characters intergrading to some extent. In the short snout it agrees with *H. hippocampus* Linnaeus (most generally designated as *H. brevirostris* by authors), but differs from the latter in having a more slender trunk, better developed tubercles, and, on the average, more numerous caudal segments and dorsal rays, and to a lesser extent also more pectoral rays. In connection with this study, 9 specimens of *europaeus*, 4 of *hippocampus*, and 24 of *guttulatus* have been examined. Study of a larger series might possibly show a greater degree of intergradation and a subspecific status for *europaeus* might be thought desirable, but there is no doubt that it is recognizably distinct from either of the two common Mediterranean species.

Hippocampus reidi, new species

Description of type specimen: The brood pouch well developed, extending to fifth caudal segment. Trunk segments 11. Caudal segments 37. Dorsal rays 17. Pectoral rays 16. Tubercles obsolescent. Coronet markedly low and blunt. Trunk notably slender. Length 121 mm.; depth 15.2; head 22.6; snout 11.2; eye 3.6; postorbital 9.8; trunk 33.4; and tail 62.2 per cent of length. Covered densely with small brown spots against a lighter background; ground color profusely sprinkled with minute, almost microscopic, white dots.

Holotype: U.S.N.M. Cat. No. 86590; St. George, Grenada, British West Indies; W. O'Brien Donovan. I have also studied specimens of this species from Porto Bello, Panama; Jamaica, West Indies; and Port-au-Prince, Haiti.

Discussion: This species is evidently close to *H. punctulatus* and may be distinguished from the latter by its markedly slender trunk, when specimens of like size and the same sex are compared, the comparatively lower coronet, the absence of tubercles on the upper margin of the trunk, and the markedly different color pattern. In its obsolescent tubercles it nearly agrees with *H. hippocampus* from the Mediterranean, differing from the latter in its slender body, longer snout and the pectoral rays being more numerous on the average.

The species is named for Mr. Earl D. Reid, Aid in the Division of Fishes of the U. S. National Museum.

Hippocampus obtusus, new species

Description of type specimen: Brood pouch just beginning to develop, in form of elliptical fold of skin on anterior 4 caudal segments. Trunk segments 11. Caudal segments 35. Dorsal rays 17. Pectoral rays 16. Every third spine on trunk and every third or fourth on anterior part of tail having a peculiar and characteristic form, very stout and very obtuse, reduced to stout stumps. Coronet of medium height. Length 70 mm.; depth 11.8; head 24.5; snout 10.7; eye 4.4; postorbital 10.8; trunk 35.2; and tail 60.9 per cent of length.

Holotype: U.S.N.M. Cat. No. 84527; secured by the *Albatross* from off Cape Hatteras, North Carolina; June 5, 1885.

Discussion: Although this specimen was taken within the geographic range of *hudsonius* and the counts of its meristic characters also fall within the range of variation of that species, it evidently represents a distinct species, separable chiefly by the peculiar structure of the tubercles. The trunk in the present species is conspicuously more slender, even more so than the extreme variants of the specimens of *hudsonius* which have been measured. The specimen described has been compared with over 70 specimens of *hudsonius.*

Hippocampus hildebrandi, new species

Description of type specimen: No rudiment of a brood pouch, probably a female. Trunk segments 11. Caudal segments 39. Dorsal rays 21. Pectoral rays 17. Every third or fourth spine on upper ridge of trunk and anterior part of tail conspicuous as a stout but short and stumpy projection, the appearance very characteristic. Coronet of medium height. Length 68 mm.; depth 13.7; head 24.4; snout 10.2; eye 4.4; postorbital 10.6; trunk 30.1; and tail 65.4 per cent of length. No definite color pattern discernible.

Holotype: U.S.N.M. Cat. No. 82063; Chame Point, Pacific coast of Panama; Robert Tweedlie.

Discussion: This species is the Pacific coast counterpart of *H. obtusus,* differing from the latter in the more numerous dorsal rays and caudal segments.

I take pleasure in naming this species after Dr. Samuel F. Hildebrand, Ichthyologist, of the U. S. Bureau of Fisheries.

Hippocampus regulus, new species

Description of type specimen: A male with the brood pouch fully developed. Length 30.5 mm.; depth of trunk 18.4; head 22.6; snout 6.9; eye 5.9; postorbital part of head 12.1; length of trunk 33.8; and tail 62.3 per cent of length. Dorsal rays 11. Pectoral rays 11. Trunk segments 10. Caudal segments 30. Coronet conspicuously high. Tubercles of medium development. Color dark, faintly shaded with lighter; no definite color pattern.

Holotype: U.S.N.M. Cat. No. 92950; Harbor Island, Texas; May, 1927; J. C. Pearson. Specimens studied also from Cat Island, Miss., Hog Island, Texas; Champoton, Campeche, Mexico (Zoological Museum, University of Michigan).

Discussion: This species differs from *H. zosterae* Jordan and Gilbert chiefly in having fewer dorsal rays and caudal segments, although there is more or less intergradation in these characters.

ZOOLOGY.—*Some Greenland hydroids.*[1] C. McLean Fraser, University of British Columbia. (Communicated by Waldo L. Schmitt.)

The small collection of hydroids obtained by Captain R. A. Bartlett in the course of his expeditions to the coasts of Greenland and Baffin Land, 1925–32, and entrusted to me for report through Dr. Waldo L. Schmitt of the United States National Museum, has proved to be of considerable interest.

There are four lots in the collection. From the east coast of Greenland, some hydroid material was obtained in Clavering Fiord, near Clavering Island (10–35 fathoms), in Lat. 74° 20′ N., Long. 21° W., on August 2, 1930. From west of Greenland, the largest lot was obtained off Cape Alexander at the entrance to Smith Sound, in approximately Lat. 78° 15′ N., Long. 75° W., on August 26, 1932. Another lot was obtained 60 or 70 miles farther south, 5 miles south of Cape Chalon (Prudhoe Land), on July 27, 1932. Finally, a few specimens were obtained from the southern corner of Fox Basin (34–37 fathoms), in Lat. 66° 46′ N., Long. 79° 15′ W., on August 13, 1929. As Fox Basin is separated from the Greenland waters by Baffin Land, these are not strictly Greenland hydroids, but as there were only two species, both of which have been obtained from Greenland waters, they are included here.

[1] Received September 5, 1933.

Twenty-two species in all were obtained, 15 from east of Greenland, 17 from west of Greenland, 10 being common to the two. The ten common species were:

Eudendrium tenellum Allman
Campanularia integra (MacGillivray)
Calycella syringa (Linn.)
Halecium curvicaule v. Lorenz
Halecium muricatum (Ellis and Solander)
Halecium tenellum Hincks
Grammaria abietina (Sars)
Lafoea fruticosa Sars
Lafoea gracillima (Alder)
Sertularella tricuspidata (Alder)

Those found in the eastern collection but not in the western were:—

Garveia groenlandica Levinsen
Eudendrium ramosum (Linn.)
Filellum serpens (Hassell)
Hebella calcarata (Agassiz)
Sertularella tenella (Alder)

Those found in the western collection but not in the eastern were:—

Campanularia groenlandica Levinsen
Campanularia verticillata (Linn.)
Campanularia volubilis (Linn.)
Obelia longissima (Pallas)
Cuspidella grandis Hincks
Halecium labrosum Alder
Thuiaria thuja (Linn.)

The collections are not very different from previous Greenland collections but as they were obtained from locations previously unexplored, the known distribution of the various species is extended.

Of the 15 species from Clavering Fiord, four have not been reported previously from east Greenland. Two of these, *Cuspidella grandis* and *Sertularella tenella,* have been obtained from the Arctic regions both to the eastward and to the westward, hence it is not surprising that they are found here. The other two, *Eudendrium ramosum* and *Hebella calcarata,* have not previously been reported from such high latitude. *E. ramosum* has been reported from the Pacific Coast and the Atlantic coast of North America and from western Europe. This

serves as the first record to connect up the distribution in these three areas as it is connected up in many other species.

With *Hebella calcarata*, the case is somewhat different. It has a wide distribution but in areas apparently little related to those in which the other species are found. The nearest recorded locality is off Nova Scotia. From this as a farthest north, it is distributed along the Atlantic coast of North America, south to Florida, on the west coast of Africa, different areas in the Indian ocean, off Japan, Australia and New Zealand, all in comparatively low latitudes.

From the west coast, all of the species but one (*Thuiaria thuja*), listed, were found off Cape Alexander. These have all been reported from the west coast of Greenland, but I believe they have never before been reported from so far north. It is quite possible that hydroids have not been obtained so far north previously in any region. As the colonies of hydroids were just as luxuriant as those growing elsewhere, frigidity does not seem to be a factor detrimental to growth.

The locality near Cape Chalon is not far enough away from Cape Alexander to expect a difference in fauna. Six species were obtained; *Campanularia groenlandica, Halecium curvicaule, H. muricatum, Grammaria abietina, Lafoea gracillima* and *Sertularella tricuspidata.*

TABLE 1.—DISTRIBUTION OF HYDROIDS

Species	PNA	WArct	ANA	WG	EG	EArct	WE
Garveia groenlandica	0	0	0	0	0	0	—
Eudendrium ramosum	0	—	0	—	0	—	0
Eudendrium tenellum	0	0	0	0	0	0	0
Campanularia groenlandica	0	—	0	0	0	0	0
Campanularia integra	0	0	0	0	0	0	0
Campanularia verticillata	0	0	0	0	0	0	0
Campanularia volubilis	0	0	0	0	0	0	0
Obelia longissima	0	0	0	0	0	0	0
Calycella syringa	0	0	0	0	0	0	0
Cuspidella grandis	0	0	0	0	—	0	0
Halecium curvicaule	—	—	0	0	0	0	0
Halecium labrosum	0	0	0	0	0	0	0
Halecium muricatum	0	0	0	0	0	0	0
Halecium tenellum	0	0	0	0	0	0	0
Hebella calcarata	—	—	0	—	0	—	—
Filellum serpens	0	0	0	0	0	0	0
Grammaria abietina	0	—	0	0	0	0	0
Lafoea fruticosa	0	0	0	0	0	0	0
Lafoea gracillima	0	0	0	0	0	0	0
Sertularella tenella	0	—	0	0	0	0	0
Sertularella tricuspidata	0	0	0	0	0	0	0
Thuiaria thuja	0	—	0	0	0	0	0

From Fox Basin there were but two species, *Campanularia volubilis* and *Thuiaria thuja*.

It is of interest to note that even in a small collection like this there is such definite evidence that most of the species reported from the higher latitudes in the northern hemisphere have had their origin in the polar area, from which area they have been distributed throughout the circumpolar regions and then south along the coasts of the continents.

Of the 22 species listed, all but two have been reported from the Pacific Coast of North America, all but seven, from the Arctic regions west of the area under consideration, all of them from the Atlantic coast of North America, all but two from the Arctic regions to the eastward, and all but two from western Europe. The larger number unreported from the western Arctic is probably due to the small amount of collecting rather than to the actual absence of the species.

The accompanying table illustrates the distribution of the 22 species. PNA indicates the Pacific coast of North America; WArct, the Arctic regions to the westward; ANA, the Atlantic coast of North America; WG, the west coast of Greenland; EG, the east coast of Greenland; EArct, Arctic regions to the eastward; WE, West coast of Europe. A cipher indicates the presence of a species within the area indicated.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

253RD MEETING

The 253rd meeting of the Academy was an informal reception at the Bureau of Standards on March 23, 1933. About 250 persons viewed *An exhibit of certain phases of scientific work in Washington* and were informally received by Director LYMAN J. BRIGGS and President R. F. GRIGGS of the Academy.

254TH MEETING

The 254th meeting of the Academy was a joint meeting with the Medical Society of the District of Columbia, held in the Assembly Hall of the Cosmos Club on Thursday, April 20, 1933. About 100 persons were present. President ROBERT F. GRIGGS called the meeting to order and turned over the chair to Doctor FOWLER, President of the Medical Society, who introduced Doctor HENRY E. SIGERIST of Johns Hopkins University. Doctor Sigerist delivered an illustrated address on *Medicine of the Renaissance*.

CHARLES THOM, *Recording Secretary*.

RECENTLY ELECTED TO MEMBERSHIP IN THE ACADEMY

CLARIBEL RUTH BARNETT, librarian, U. S. Department of Agriculture Library, was elected to membership in recognition of her long experience in cataloging and classifying scientific literature, in managing scientific libraries and in carrying on scientific bibliographic research.

NELLIE A. BROWN, associate pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, was elected to membership in recognition of her work on the bacterial diseases of plants.

SAMUEL B. DETWILER, principal pathologist in charge, Division of Blister Rust Control, Bureau of Plant Industry, was elected to membership in recognition of his work on forest tree diseases and their control.

HORACE S. ISBELL, chemist, Bureau of Standards, was elected to membership in recognition of his contributions to the chemistry of carbohydrates.

WILLIAM M. MANN, director, National Zoological Park, Smithsonian Institution, was elected to membership in recognition of his contributions to entomology and to the maintenance and development of zoological parks.

ROBERT D. RANDS, senior pathologist, Division of Sugar Plant Investigations, Bureau of Plant Industry, was elected to membership in recognition of his contributions to plant pathology and in particular for his researches on the diseases of rubber, cinnamon, and sugar cane.

HARRY W. SCHOENING, chief, Pathological Division, Bureau of Animal Industry, was elected to membership in recognition of his researches in the field of veterinary pathology.

JAMES S. SIMMONS, director of laboratories, Army Medical Center, was elected to membership in recognition of his contributions to medical bacteriology.

ROBERT E. SNODGRASS, senior entomologist, Division of Insect Morphology, Bureau of Entomology, was elected to membership in recognition of his contributions on insect anatomy.

LOUISE STANLEY, chief, Bureau of Home Economics, was elected to membership in recognition of her investigations on the problems of home economics and food chemistry.

LANSING S. WELLS, associate chemist, Bureau of Standards, was elected to membership in recognition of his studies on the heterogeneous equilibria between aqueous and metallic solutions and the hydration of Portland cement.

GEOLOGICAL SOCIETY

501ST MEETING

The 501st meeting was held at the Cosmos Club, March 8, 1933, President C. N. FENNER presiding.

Informal communications.—DAVID WHITE exhibited specimens of layered grits of Lower Pennsylvanian age from Orange and Perrin counties, Indiana. Lighter colored layers, about $\frac{3}{8}$ inch thick, which are used in the manufacture of whetstones, are separated by thinner zones in which there are two dark bands richer in carbonates and organic matter. The dark bands, correlated by Dr. White with times of slack sedimentation, are believed by him

to reflect a seasonal hot dry climate, since xerophytic plant fossils are found associated with them.

FRANK L. HESS exhibited carbonate oolites about the size of small peas from a well 3,125 feet deep in Union County, Arkansas. Almost all the oolites have at least one "dimple" on the outer surface and some have four or five. He suggested that the oolites were probably formed in the churning water of the well.

Program: PARKER D. TRASK and HARALD E. HAMMAR: *Some relations of the organic constituents of sediments to the formation of petroleum.*—This paper is a preliminary report of the results of the first 18 months investigation of source beds of petroleum conducted by the United States Geological Survey and the American Petroleum Institute. Most of the work has dealt with methods of investigation, but several tentative inferences have been reached.

In the Santa Fe Springs oil field in California the ratio of oil production to organic content of the sediments (after preliminary extraction with CCl_4) appears to be fairly constant throughout the eight producing zones in the field. It would seem more likely therefore that the oil in any individual zone was generated largely from the sediments in that zone rather than from sediments in some other zone—that is, the sands and silts contiguous to the oil actually are source beds. As the sediments in the oil zones consist largely of fine-grained sands, it would seem that under certain conditions oil may be generated from sands. The organic content of sediments is consistently small throughout the entire 4,000 feet of producing beds and is of the order of magnitude of 1.5 per cent. This small quantity of organic matter suggests that some low grade sediments are satisfactory source beds of oil and that mere richness in organic content is not necessarily a characteristic of source beds.

The volatility of the organic content of the sediments in general increases from the uppermost producing zone to the lowermost producing zone—that is, the organic constituents of the deepest and oldest beds contain much more volatile matter than do those of younger beds 4,000 feet above.

The available data indicate that the nitrogen content of the organic matter in general decreases with the age of the rocks. Carboniferous sediments contain about one half as much nitrogen with respect to the organic content, and Pliocene sediments about two-thirds as much, as do recent sediments. That is, two-thirds of the nitrogen that disappears is lost in one-tenth the time. This indicates that the nitrogen compounds are altered to a much larger extent shortly after their deposition than they are after they have been buried for a long time. This phenomenon suggests, therefore, that the period of time immediately following the deposition of sediments is of major importance in the generation of petroleum. However, as the nitrogen compounds continue to change even after a long interval, as indicated by the significant loss in nitrogen between Pliocene and Carboniferous, it seems that it could be possible to have more than one period of petroleum generation. (*Authors' abstract.*)

Discussed by Messers. D. WHITE and MONROE and Miss T. STADNICHENKO.

ELEANORA B. KNOPF.—*New methods for attacking the problems of metamorphism.*

Discussed by Messrs. GILLULY, GOLDMAN, KING, C. P. ROSS, BOWEN, and MERTIE.

502ND MEETING

The 502nd meeting was held at the Cosmos Club, March 22, 1933, President C. N. FENNER presiding.

Informal communications.—J. C. REED showed lantern slides of a large spring, 50 feet in diameter, at the foot of Muldrow glacier on the north side of the Alaska Range. The spring feeds the headwaters of McKinley Fork of Kantishne River, and continues to flow at temperatures well below freezing, for during cold weather an ice wall about 6 feet high builds up around the spring. Mr. Reed suggested that the spring marks the emergence of a subglacial stream from a portion of the glacier concealed by the river gravels.

Program: JAMES GILLULY: *Internal evidence of the origin of certain schists.*—The important results of recent studies of metamorphic rocks, especially by Sander and Schmidt in Austria, include the discovery that the systematic anisotropy of the rock fabric is commonly correlatable with the tectonic movements which the rock has undergone. Most of their work has been on the dynamometamorphosed east Alpine rocks and such a correlation is perhaps not unexpected. It appeared worth while to apply the methods of Schmidt to the problem of the conditions of metamorphism of rocks whose characters are commonly attributed to static or load metamorphism.

Professor Daly, whose report on the Shuswap terrane of interior British Columbia contains a clear description of supposedly load-metamorphosed rocks, very kindly sent me specimens and thin sections for study.

If the metamorphism of the Shuswap rocks were purely static one would anticipate that the contained minerals would have an arrangement symmetrical with respect to the normal to the schistosity. A statistical study of the orientation of the quartz and biotite of two specimens of the rocks showed, however, a decided arrangement in a girdle, not oriented parallel to the schistosity, but normal to the schistosity. This is the arrangement found in many dynamometamorphosed rocks and seems to indicate that, whatever the cause of the metamorphism, the orientation of the minerals as now seen is a result of systematic differential movement between the component grains. The planes of schistosity have acted as shear planes. In the laboratory it is of course impossible to determine whether or not these differential movements correlate and integrate to large scale deformation, but it appears that the orientation pattern in the Shuswap rocks is precisely analogous to that found in the Alpine tectonites. It can safely be said that whether or not the metamorphism of the Shuswap rocks is due to load it was surely not static. The present rock fabric bears unmistakable evidence of kinetic effects.

In view of these features, the possibility that the Shuswap rocks were metamorphosed during flat overthrusting like that of the Alps must be given consideration, though naturally this possibility must be investigated in the field. It is not yet clear that a distinction can be made between yielding under load and consequent lateral flow on the one hand, and tangential movement of great masses on the other. (*Author's abstract.*)

Discussed by Messrs. STOSE, HESS, BUTTS, PARKER, RUBEY, FENNER, and Miss JONAS.

C. WYTHE COOKE: *Origin of the so-called meteorite scars of South Carolina.*—In the Journal of Geology, 41: 52–66, 1933, F. A. Melton and William Schriever describe certain low elliptical sand ridges near Myrtle Beach, S.C.,

that are conspicuous in aerial photographs and suggest that they may surround scars made by meteorites. The ridges are remarkable for their symmetry in plan and for the fact that the major axes of all the ellipses are parallel to one another and extend at right angles to the seashore.

Study of the photographs reveals many details of form that are characteristic of the work of waves and currents on unconsolidated sand. All the elliptical ridges border or lie within ancient waterways that were active during the late Pamlico epoch of the Pleistocene, when sea level stood 25 feet higher than now. The ridges appear to be beaches and sand bars built by wind-driven currents and waves before the waterways became clogged by vegetation. The ellipses are oriented alike probably because the winds that propelled the waves and currents that shaped them blew from the ocean. (*Author's abstract.*)

Discussed by Messrs. W. C. Mansfield, D. White, Thompson, Rubey, Bridge, and Hendricks.

David White: *Pre-Cambrian seas?*—Recalling that limestones, calcareous shales, and black shales, such as are in general regarded as characteristic of marine deposits, are extensively found in all areas of not too altered Algonkian, and emphasizing especially the prevalence of thick limestone formations in the Proterozoic—e.g., 50,000 feet (see Adams and Barlow) in the Grenville of Ontario, about 5,000 feet in the Canadian Northwest, 7,500 feet in the Belt region, over 1,200 feet in northern Arizona, 2,500 feet more or less in Siberia, 6,000 feet in China, and considerable thicknesses in India, Australia, and South Africa—the speaker insisted that the burden of proof that the known pre-Cambrian is entirely of fresh water origin rests with the geologists who still hold to that view.

The conclusion, based on lack of faunas identified as marine, that all pre-Cambrian basins of marine deposition foundered without trace before Cambrian time, never to reappear, postulates not only a sudden post-Algonkian departure in geotectonics, but also a reversal of geologic processes. Otherwise, where are the great fresh water limestone formations and heavy non-marine calcareous shale series of the Cambrian, Ordovician, and Silurian? Ripple marks, suncracks, and salt hoppers are very common in the Algonkian, but they are not peculiar to it.

Failure to discover marine animals approaching the Cambrian in form and diversity in association with the Algonkian deposits of carbonaceous matter, sedimentary iron, algal limestone, and some remains identified as animal, finds explanation in uranium lead ratios, which indicate ages of 780 million years for the late Huronian, and 1060 million years for earlier Huronian, possibly, but less than 475 millions—less than one-half as much—for early Cambrian. The life remains found in the recognized late pre-Cambrian series are representative of the sea life of the time. This life has its own characteristics and already promises bases for very rough paleontological correlations, as is shown by the presence of distinctive American forms of algal deposits in the Canadian Northwest, Siberia, China, and Australia. The great blossoming out of pre-Cambrian animal life was later than the Huronian and probably much later than the Belt series, which, but for the compensation of tremendous horizontal stresses by the Lewis and other overthrusts of the region, might well have been as far altered as the Huronian of the Lake district and possibly as the Grenville of the Adirondack and Laurentian regions. The records of most brilliant life evolution before the Cambrian should be found in rocks dated within the 200 million years pre-

ceding the earliest Cambrian, or more than 100 million years later than the Huronian or possibly the Animikie. (*Author's abstract.*)

Discussed by Messrs. RESSER and HEWETT.

503RD MEETING

The 503rd meeting was held at the Cosmos Club April 12, 1933, President C. N. FENNER presiding.

Informal communication.—ROBERT KING described an area of Permian rocks in Mexico, several hundred miles south of the nearest outcrops in Texas. This area of 171 square kilometers is on a pediment on each side of a plateau between the two branches of the Sierra Madre, which are composed of folded Cretaceous rocks. The Permian section has a maximum thickness of 11,000 feet, but much of this thickness is due to the inclusion of surface volcanic rocks. The beds represented include both the highest and lowest portions of the Permian as known in North America. They are folded into a syncline, and are cut by thrust faults. Nearby flat Cretaceous beds overlie the Permian beds unconformably. Thus the relations here differ notably from those the Trans-Pecos Texas region, where the major deformation is pre-Permian.

Discussed by Mr. J. S. WILLIAMS.

Program: P. J. SHENON and J. C. REED: *The relationship of the quartz veins to the regional structure in the Elk City district, Idaho.*—The gold-bearing quartz veins of the Elk City district of north-central Idaho stand nearly at right angles to a linear elongation of minerals in the country rocks. This linear element is to be distinguished from the more commonly recognized schistosity or planar foliation of gneissic and schistose rocks.

Banded gneiss is the most abundant rock in the district. It is interbedded with schist and quartzite and in some places these rocks have been intruded by sills and dikes. Irregular bodies of augen gneiss lie transverse to the trend of the banded gneiss and schist. Granodiorite crops out over a large area and extends beyond the limits of the district. Most of the veins lie within two miles of the gradational contact between the granodiorite and the older gneiss and schist.

The right-angle relationship between the veins and the mineral elongation appears to be genetic because the measured orientations of the veins do not differ from a position at right angles to the elongation by more than might be expected considering the errors inherent in the data used. Furthermore, the departures from a 90 degree relationship appear to be systematic as most of the veins dip somewhat more steeply than they would if they were exactly normal to the mineral elongation.

Hans Cloos and others have shown that a right-angle relationship exists between a linear element, called "stretching," and a set of "Q" or cross joints in certain igneous rock masses. The same phenomenon has also been observed in metamorphic rocks. According to Cloos and his associates the "stretching" is a result of mineral orientation during flow, and the "Q" joints develop at a slightly later stage by tension at right angles to the "stretching." In this paper the relationship between the veins and the mineral elongation is compared to that between the "stretching" and the "Q" joints, but statements concerning the origin of the fractures containing the veins are avoided because a much greater areal study will be necessary before adequate data for positive conclusions can be gathered, and also be-

cause the writers are not convinced that they necessarily form in the manner postulated by Cloos.

An understanding of the relationship between the veins and the elongation will be of economic importance as a guide to prospecting and as a factor in forming a conception of the probable extent and attitude of veins and ore bodies both horizontally and in depth. (*Authors' abstract.*)

Discussed by Messrs. GILLULY, TRASK, and JOHNSTON.

FRANÇOIS E. MATTHES: *The Pleistocene diversion of the Mississippi River across Crowleys Ridge, southeastern Missouri.*—A short distance below Cape Girardeau, Mo., the Mississippi River abruptly leaves the broad cliff-lined trench which it has carved across the limestone uplands of Missouri and Illinois, and, turning south-southeastward, cuts across Crowleys Ridge in a narrow rock floored gorge. It then debouches upon the broad lowland to the southeast of the ridge which originally was the path of the Ohio, and meets that river at Cairo. There is abundant evidence showing that before this remarkable diversion took place the Mississippi continued along the west side of Crowleys Ridge, and met the Ohio at some point below the site of Helena, Ark., fully 200 miles below the present point of confluence.

The only hypothesis to account for the Mississippi's diversion across Crowleys Ridge has been offered by C. F. Marbut and is to the effect that the river was captured by a south-southeastward flowing streamlet on the broad surface of the ridge that was tributary to the Ohio. During the Pleistocene epoch, when it flowed immediately along the southeast side of Crowleys Ridge, the Ohio presumably lay at a somewhat lower level than the Mississippi, and owing to this circumstance and the fact that the southeastern margin of Crowleys Ridge is composed of weak unconsolidated sediments of Tertiary age, whereas the northwestern margin is composed of hard Paleozoic rocks, the hypothetical south-southeastward flowing streamlet had a double advantage over the northwestward flowing streamlets tributary to the Mississippi, and was able to capture one of these as it eroded headward. A low gap was thus formed in the ridge, and through this gap eventually the waters of the Mississippi found their way when the bed of the river was raised by aggradation to a sufficiently high level.

Marbut went further and supposed the Mississippi to have been diverted by this process of indirect capture three times in succession at different points in southeastern Missouri—first through the gap in Crowleys Ridge now traversed by Castor River, then through the gap now traversed by Little River, and finally through the gorge now occupied by the Mississippi. However, the drainage pattern on this portion of Crowleys Ridge affords no indications whatever of rapidly headward growing streamlets tributary to the Ohio, either at the gaps mentioned or elsewhere. On the contrary, it shows only northwestward draining streamlets whose maturely developed ramifications were never disturbed by pirate streams. Moreover, the southeastern margin of Crowleys Ridge is indented only by short ravines, and it is apparent that there has not been sufficient time for the headward growth of pirate streams 8 or 9 miles in length, nearly across the width of the ridge, as is demanded by Marbut's theory. That theory, therefore, does not appear well founded.

Recent investigations in southeastern Missouri have revealed the presence of numerous terrace-like remnants of ancient flood plains of the Mississippi in protected recesses on the sides of the different gaps in Crowleys Ridge, likewise in the abandoned valley of the Mississippi between the ridge and

the Ozark Highland, and along the sides of the Mississippi trench at and above Cape Girardeau. These terraces are composed of stratified silts and sands containing a large proportion of granitic and other crystalline material of northern origin. The highest and oldest, which stand 50 to 60 feet above the present flood plain of the Mississippi, are in part covered by loess. There can be no doubt that they are remnants of a filling of glacial outwash derived from the later ice sheets that lay to the north of the area.

The topographic relations of the upper terraces are such as to indicate that at the time of maximum aggradation the waters of the greatly swollen Mississippi spilled simultaneously through a number of shallow gaps in the sky line of Crowleys Ridge. These gaps or spillways consisted of originally northwestward draining valleys that had been beheaded by the progressive paring away of the southeastern margin of the ridge by the Ohio River.

After the period of maximum aggradation the river cut down the main spillways to successively lower levels. The old Mississippi valley along the northwest side of Crowleys Ridge, however, remained obstructed by sediment, and so when the waters contracted in volume they abandoned that valley. At a later stage they abandoned the broad gap through which Little River now finds its way, and they remained confined to the narrow gorge which the river still occupies. That gorge presumably afforded the most direct and steepest channel to the Ohio, and its narrowness doubtless helped to maintain a concentrated current and to prevent deposition.

Discussed by Messrs. ALDEN, HENBEST, SEARS, STEPHENSON, THOMPSON, and FENNER.

504TH MEETING

The 504th meeting was held at the Cosmos Club April 26, 1933, President C. N. FENNER presiding.

Program: W. T. SCHALLER: *Correlative mineralogy of the potash mine, New Mexico.*

Discussed by Mr. LANG.

VINCENT P. GIANELLA and EUGENE CALLAGHAN: *The Cedar Mountain, Nevada, earthquake of December 20, 1932.*—An earthquake of major intensity originated in the area east of the Gabbs Valley Range and Pilot Mountains, near Mina, southwest of the center of Nevada on December 20, 1932, at about 10:04 P.M. P.S.T. It was definitely perceptible over an area of about 400,000 square miles including Nevada and parts of California, Oregon, Idaho, Utah, and Arizona. A circle including the scattered outermost points from which reports were received would have an area of nearly 1,000,000 square miles. It is remarkable, however, that no lives were lost and damage was confined to the demolition of one stone cabin and an adobe cabin, damage to ore-treating plants and mines, broken chinaware and crockery, and minor items. Several factors may be held to account for this, including the sparse population (there were scarcely a dozen people in the epicentral area), location of nearly all structures on rock, lack of water-soaked alluvial fill, and probable great depth of the point of origin. There were a number of the effects noted as usual in earthquake areas, such as the change in flow of springs, avalanches of boulders down steep slopes, churning of surface soil in places and upthrown boulders in at least one place. Aftershocks are to be numbered in the thousands and were reported as still continuing on April 23, though at greatly reduced frequency and intensity.

The main shock of the earthquake accompanied the formation of a series of tension faults or rifts over an area 38 miles in length and 4 to 9 miles in

width in the lowland between the Gabbs Valley Range and Pilot Mountains on the west and Paradise Range and Cedar Mountain on the east. The lowland is an area of partly dissected pediment slopes with a thin alluvial mantle on Tertiary lake beds and volcanic rocks, whereas the mountain ranges consist largely of pre-Tertiary rocks. In many places the rifts follow breaks in slope and the margins of low hills, indicating that they are related to earlier faults. Sixty rifts in various parts of the area were observed and undoubtedly many escaped detection because of the heavy snowfall that terminated the investigation. The rifts form an en echelon pattern, as most of them have an average trend of N. 11° E., whereas the direction of the rift area is N. 21° W.

Individual rifts are from a few hundred feet to nearly four miles in length, and consist of zones of fissures that range from a few feet to several hundred feet in length. Individual fissures generally trend more to the northeast than the direction of the rift, except in those places where the rifts trend more to the east than N. 35° E. This gives them an en echelon pattern within the rifts. Vertical displacement may be either to the east or the west and the throw is generally less than a foot. Horizontal movement is indicated by compression ridges on fissures at a sharp angle to the direction of some of the rifts and by actual horizontal displacement of as much as 34 inches. Grabens are common features of most of the rifts and may be as much as 100 feet wide, with a wall four feet high on one side and two feet high on the other. Most of them are less than 15 feet in width with a displacement of less than a foot.

The en echelon pattern of the rifts and the remarkable uniformity of en echelon pattern of fissures within the rifts together with evidence of actual horizontal movement with the east side toward the south, indicate that the rifts were caused by a definite directional stress. This can be explained as the result of a southward shift of the Paradise Range and Cedar Mountain block on the east in reference to the Gabbs Valley Range-Pilot Mountains block on the west. It resembles the movement on the San Andreas rift, except that its movement was distributed over a zone several miles wide rather than a few hundred feet. A possibility of origin due to differential uplift causing torsional stress may be entertained but is not readily demonstrable. (*Authors' abstract.*)

Discussed by Messrs. SEARS, FERGUSON, and KING.

A. F. FOERSTE: *The migration of certain Paleozoic arctic faunas.*
Discussed by Mr. RESSER.

505TH MEETING

The 505th meeting was held at the Cosmos Club May 10, 1933, President C. N. FENNER presiding.

Informal communications.—A. R. BARWICK of Catholic University exhibited some specimens of Triassic shale of the Newark formation from Virginia which showed calcareous structures which he suggested might be fossil Ostreidae. A part of the Newark deposits therefore, may possibly be of marine origin.

F. E. MATTHES presented a brief note on the discovery of what is known as the Stadter Buried Forest on Mount Hood, Oregon—a tangled mass of tree trunks protruding from beneath a moraine of the Zigzag Glacier. This overridden forest, though situated near the level of the present timber line, was composed of tall, straight trees, including species that now occur 1,000

to 2,000 feet lower down. The number of annual rings per inch, moreover, is characteristic of tree growth at the lower levels. The buried forest, therefore, appears to indicate that prior to the ice advance there was a prolonged period of climatic conditions milder than those that prevail at the present time. Corroborative evidence is found in the northern part of the Cascade Range. It seems entirely probable, in view of the great altitude at which these remnants of ancient rain forests occur, that during the mild period postulated the Cascade Range bore no glaciers, save possibly a few on its highest peaks. It follows that nearly all of its present glaciers, and probably all those on the Sierra Nevada and the Rocky Mountains, have come into existence during relatively recent times and are not to be regarded as remnants of the great glaciers of the Pleistocene epoch.

Discussed by Messrs. HESS and BUTTS.

Program: J. P. MARBLE: *Some recent developments in the Pb/U method for age determinations.* The importance of fresh, unaltered, primary material for analysis was stressed, also the need for thorough geologic and petrographic studies on minerals and rocks. Wherever possible the atomic weight of lead in the mineral as analyzed should be determined. Recent work shows the existence of pure uranium lead in minerals. The value and applications of magneto-optic method of study and the reliability of some recent determinations were discussed, and the need for new data along several lines pointed out. Preliminary analyses on a pitchblende from Great Bear Lake, N.W.T., Canada, giving a Pb/U ratio of 0.201, and apparent "corrected" age of about 1375 million years, were discussed on the above basis. Final figures await further study, and the receipt of more satisfactory material. (*Author's abstract.*)

Discussed by Messrs. HESS, and R. C. WELLS.

M. N. BRAMLETTE: *Rhythmic bedding in the Monterey rocks of California.*—A conspicuous rhythmic bedding occurs in these rocks in which the beds are generally between one and two inches thick, and each shows a distinct sequence of deposition with sand at the base, grading upward through finer clastic material to an upper zone of organic deposition—largely diatoms. The various processes that might produce such bedding have been considered and the tentative conclusion reached that annual cycles best fit the evidence, that is, that these layers are marine varves.

Whatever the period of this rhythmic bedding, some significant conclusions may be drawn from the fact that, in order to have been preserved, it indicates deposition below effective wave action. Such conditions result in various distinctive features as contrasted with the more usual sedimentary deposition above wave base. Accumulation of organic matter would be favored, and it is suggested that such rhythmic bedding or the analogous fine lamination in sedimentary formations may be as significant as is fine grain size, in indicating good source beds of petroleum. (*Author's abstract.*)

TEIICHI KOBAYASHI: *A sketch of Korean geology.*—Three phases of the geology of Korea were emphasized; (1) Generally speaking, Manchuria, Chosen and China, together with Indochina and India, comprise one paleographical province in the Cambrian, while in the Ordovician the area was divided into two distinct provinces by the Tsin-ling-Keijo line. The faunas in the Tsinan Basin which covers north China, South Manchuria and north Chosen are closely allied to those of the Arctic and American regions, whereas some of the southern faunas, occurring in south Chosen, central

and south China, Indochina, and Burma, bear an unmistakable relationship to European faunas. (2) During the Jurassic, probably in the middle of the period, a considerable crustal movement occurred in the Korean peninsula. Pressure from the north made the configuration of the fundamental geologic structure, notably the Liaotung direction in the Heinan trough and the Sinian direction in the Yokusen trough; this was followed by tremendous igneous activity in the Cretaceous. (3) In the Cenozoic elevation of the peninsula and depression of the Japan Sea occurred repeatedly—both movements attaining their maximum near the Korean coast. Further, the Cenozoic movements on the whole resulted in the construction of an asymmetrical geanticline on the peninsula and a similar geosyncline in the Sea of Japan. Of the repeated movements the most important is the Miocene revolution which was responsible for the upheaval of the Kaima plateau and the back bone range of the peninsula. (*Author's abstract.*)

Discussed by Mr. Foerste.

W. H. Bradley and T. B. Nolan, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

U. S. Public Health Service.—The Public Health Service is investigating the outbreak of amebic dysentery which started in Chicago hotels and restaurants during the Century of Progress exposition, and which has thus far resulted in over fifteen deaths.

An antidote for mercuric bichloride has been discovered by Dr. S. M. Rosenthal of the U. S. National Institute of Health. It has already been used successfully to treat a victim of bichloride poisoning. The antidote is still admittedly in the experimental stage. However, results with animals poisoned by bichloride have been very good and the successful result with the first human case is considered encouraging. The new antidote, said to be the first known for mercuric bichloride is formaldehyde sulfoxylate. It is administered simultaneously by mouth and by intravenous injection. Bichloride poisoning is not very common, so that it may be some time before physicians have enough experience with the new remedy to determine its value. Dr. Rosenthal has asked Washington hospitals to notify him of any cases so that he may assist them in using the new antidote if they wish it.

Wellcome Prize and medal.—The Wellcome Prize, consisting of $500 and a gold medal, was for 1933 awarded to Major Edgar Erskine Hume, Medical Corps, U. S. Army, Librarian of the Army Medical Library, for his essay, *The value of studies in health and sanitation in war planning.* The Wellcome Prize was established in 1916 by Sir Henry S. Wellcome of London, and is awarded annually by a board of judges appointed by the Association of Military Surgeons. Honorable Mention, which includes life membership in the Association, was awarded Lieutenant-Colonel Paul W. Gibson of the Army War College.

Pan American Medical Association.—The Washington Chapter of the Pan American Medical Association held its first meeting of the winter season on November 10 at the Peruvian Embassy. The session was devoted to the

memory of the noted Latin-American physician-statesman Hipolito Unanue (1755–1833), recalling his many contributions to science, meteorology, medicine, education, literature, and last but not least national progress. Drs. J. G. Lewis, E. Gil Borges, Prentiss Willson, J. G. Trible, T. Cajigas and A. A. Moll spoke. The Peruvian Ambassador, Dr. Manueld de Freyre y Santander, recalled in a masterly address the many-sided career of Unanue, concluding "What medicine may have lost through his manysidedness Peru gained." The next meeting of the Chapter on December 3 will be devoted to Finlay (1833–1915), the discoverer of the transmission of yellow fever by the mosquito.

A paper by Dr. A. A. Moll, of the Pan American Sanitary Bureau, on the career of Finlay has been published in the Bulletin of the Pan-American Union for December.

Bureau of Biological Survey.—The Bureau of Biological Survey has begun a special study of wild-fowl baiting, to be carried on throughout the present open seasons along with an investigation of the natural food supplies and the numbers of waterfowl and shorebirds. Twelve members of the Bureau's staff are observing conditions in practically all the principal areas on which wild fowl are shot in the United States, and Federal game protectors throughout the country are making observations supplementing the work of the special investigators. The following members of the Bureau's Washington staff are engaged in this work in the areas named: Clarence Cottam, coastal waters from Maine to the Potomac River; Neil Hotchkiss, coastal waters from Virginia to Florida; F. M. Uhler, Illinois River Valley, Missouri, Arkansas, western Kentucky, Tennessee, and northern Mississippi; A. C. Martin, coastal Alabama, Mississippi, Louisiana, and Texas; and F. C. Lincoln, Michigan, Ohio and western Pennsylvania and New York.

Department of Terrestrial Magnetism.—Dr. J. A. Fleming returned to the Department of Terrestrial Magnetism on October 26, after having attended the very successful meetings of the International Union of Geodesy and Geophysics at Lisbon, Portugal, where he was reelected President of the Association of Terrestrial Magnetism and Electricity of that Union for the period 1933–1936. While in Europe he visited laboratories in France, Switzerland, and Germany in connection with the work of the Department.

Mr. P. G. Ledig, upon the completion of his magnetic and cosmic-ray work in South America, reported at the Department on September 28.

Lieut. J. C. Woelfel, U. S. N., of the Hydrographic Office, Navy Department, is spending a few days at the Department receiving instruction in the operation of magnetic instruments preparatory to his departure for Central America where a series of magnetic observations will be made.

George Washington University School of Medicine.—The October lecture in the Smith-Reed-Russell series at the School of Medicine, George Washington University was delivered by Prof. W. W. Cort, School of Hygiene and Public Health, Johns Hopkins University who spoke on *Recent developments in our knowledge of hook-worm disease.* The November lecture of this series will be given by Prof. James W. Jobling, College of Physicians and Surgeons, Columbia University. At the annual banquet of the Society which was held at the University Club on October 20 an address was delivered by Dr. William Charles White, Chairman of the Committee on Research of the National Tuberculosis Association. On this occasion new faculty and student members were inducted into the Society.

News Briefs

The famous Treasure of Monte Alban, in Mexico, was shown at the Pan American Union from October 30 to November 4, under the auspices of the Carnegie Institution of Washington and George Washington University. Dr. Daniel de la Borbolla, anthropologist of the Mexican National Museum, gave addresses on the Treasure and its significance at the Union and at George Washington University.

A "Rosetta stone" of ancient American culture has been brought back to the National Museum by Frank M. Setzler. It is an Indian vase found in a mound at Marksville, La., bearing decorations in the well-known Hopewell style on one side, and on the other, marks of a hitherto unknown Indian art style.

The Association of Official Agricultural Chemists met in Washington during the week of November 6.

A method of rapid determination of lead in low concentrations, stated to be extraordinarily delicate and accurate, has been worked out by chemists of the Food and Drug Administration. It has been described by H. J. Wichmann. It depends on the red color reaction when a lead-containing solution treated with ammoniated cyanide is added to a green solution of diphenyl-thio-carbazone ("dithizone") containing chloroform.

An improvement in radio beacons, permitting the simultaneous sending of four distinct signals in four different directions, has been announced by F. W. Dunmore of the National Bureau of Standards.

The Hydrographic Office of the Navy Department was represented at the Fifth Assembly of the International Union of Geodesy and Geophysics at Lisbon, September 17 to 24, 1933, by Captain David McD. LeBreton, U.S. Navy, who presented a paper on *The bathymetry and water circulation of the North Pacific Ocean, and gravity investigations of the West Indies regions.*

The Office was represented at the Fifth Pacific Science Congress June 1–9, 1933, at Victoria and Vancouver, by A. B. McManus, who presented papers on *Recent soundings, gravity investigations, and mapping sea floors*, and *Water circulation in Pacific regions.*

During the year 1933, the U.S.S. *Hannibal*, as opportunity offered during its surveying season in Central American waters, occupied a total of 144 stations. Of these 7 were in the Atlantic and Caribbean, chiefly for training of the sounding crews, 85 in a network covering the Gulf of Panama, and 52 in the littoral waters of Panama and Costa Rica.

The U.S.S. *Gannet* occupied 42 stations in the Aleutian Islands, making temperature observations and obtaining 455 water samples.

The Brookings Institution was addressed on the evening of November 10 by Dr. John Dickinson, Assistant Secretary of Commerce, on *Fundamentals of the recovery program.* On November 14, Henry I. Harriman, president of the Chamber of Commerce of the United States, spoke on *Business and the recovery program.*

A conference of state, federal and private foresters and others interested in forestry subjects was held in the auditorium of the Department of the Interior on October 26. In connection with this meeting, the Department of Agriculture presented facts and plans of the fight against the Dutch elm disease in this country.

To prevent further introductions of the Dutch elm disease fungus (*Graphium ulmi*), into this country, quarantine regulations governing the importation of burl logs from France and other European countries have been adopted. The logs may continue to enter the country, but they must first be stripped of their bark, to get rid of lurking specimens of the vector beetle, and they must also be subjected to a hot-water treatment long enough to kill the fungus. Crates and other small forms of elm lumber must be entirely free from bark.

A considerable collection of relics of the early settlement at Jamestown, dug up many years ago, has been presented to the U.S. National Museum by Martin L. Ehmann of New York.

Personal Items

Ferdinand A. Silcox, formerly with the U. S. Forest Service and now director of industrial relations for the New York Employing Printers' Association, has been appointed chief of the Forest Service, to succeed the late Robert Young Stuart.

Dr. W. A. Taylor, chief of the Bureau of Plant Industry, U. S. Department of Agriculture, will retire on January 1, 1934. He will be succeeded by Knowles A. Ryerson.

Dr. Charles Greeley Abbot, secretary of the Smithsonian Institution, was given the degree LL.D. by the University of Toronto on October 13.

Dr. F. G. Cottrell has been appointed consulting chemist of the Tennessee Valley Authority.

Dr. H. H. Bennett, formerly of the Bureau of Chemistry and Soils, U. S. Department of Agriculture, has been appointed director of the newly created Bureau of Soil Erosion service. Dr. W. C. Lowdermilk of the U. S. Forest Service has been appointed vice director.

Prof. H. R. Tolley of the University of California has been appointed chief of the section of special crops in the Agricultural Adjustment Administration.

Dr. Henry H. Pixley of the College of the City of Detroit has been appointed mathematical economist in the division of economic research and planning of the National Recovery Administration.

Dr. D. Breese Jones, chief of the protein and nutrition division of the Bureau of Chemistry and Soils, U. S. Department of Agriculture, was elected President of the Washington section of the American Chemical Society, November 9.

Edward C. Wingate, formerly topographic engineer with the U. S. Geological Survey, has been appointed to succeed Ernest P. Leavitt, as superintendent of Hawaii National Park.

Dr. George H. Hansmann, formerly assistant professor of pathology at the State University of Iowa College of Medicine, has been appointed associate professor at Georgetown University School of Medicine. Dr. James A. Gannon has resigned as associate professor of surgery at Georgetown University, after twenty-five years' association with the department.

Dr. K. S. Gibson has been appointed chief of the colorimetry section of the optics division of the Bureau of Standards. Dr. Gibson joined the staff of the Bureau in November, 1916. He succeeds the late I. G. Priest.

The following members of the staff of the Bureau of Standards attended the annual meeting of the Optical Society of America, October 19–21, at Buck Hill Falls, Pa.: Dr. B. H. Carroll, E. C. Crittenden (retiring president), Dr. K. S. Gibson, Dr. R. S. Hunter, Dr. D. B. Judd and Dr. L. B. Tuckerman (secretary).

Charles E. Kellogg, of the Biological Survey's Division of Fur Resources, spoke on October 12 at the National Rabbit Convention and Show in Chicago on feeding and other studies being carried on at the United States Rabbit Experiment Station, Fontana, Calif. He supplemented his discussion with charts and graphs.

E. A. Preble, senior biologist in the Bureau of Biological Survey, on October 11 discussed *Facts about our fur seals* at the annual meeting of the American Humane Society and associated organizations at Hartford, Conn. He illustrated his address with lantern slides. Mr. Preble was a member of the special committee appointed by the Secretary of Commerce in 1914 to study the condition of the fur-seal herds on the Pribilof Islands.

Obituary

Otis Fisher Black, senior biochemist, Bureau of Plant Industry, died suddenly in Washington, October 14. Mr. Black was born in Cambridge, Mass., March 11, 1867. He took his A.B. degree at Harvard in 1891 and served as a fellow at Northwestern University during 1892–94, receiving the degree of Master of Arts in the latter year. He was assistant chemist and instructor at Harvard, 1895–1906, and research assistant in biological chemistry, Harvard Medical School, 1906–09. He entered the Bureau of Plant Industry in 1909 as biochemist and served there continuously until his death.

Mr. Black was also a member of the American Chemical Society, the Society of Biological Chemists, and the American Association for the Advancement of Science.

Dr. Arthur Powell Davis, formerly chief engineer and general manager of the East Bay Municipal Utility District, Oakland, California, died in Oakland August 7, 1933, and was buried in Washington, D. C., August 17. Doctor Davis was born in Decatur, Illinois, Feb. 9, 1861. He received his B.S. degree from George Washington University in 1888, his Sc.D. in 1917; his D.E. from Iowa College. He was connected with government irrigation engineering problems for 20 years, first as topographer in 1882, then as hydrologist, and finally as chief engineer and director of the U. S. Reclamation Service until 1923. At various times he served as consulting engineer on Panama Canal problems, on high dam structures in Alaska, Mexico, Puerto Rico, China, Russian Turkestan, and Egypt. Just a few weeks prior to his death, Harold L. Ickes, Secretary of the Interior, appointed him a consulting engineer for the entire Boulder Canyon project in recognition of the fact that the present project is based on preliminary plans and reports made by Mr. Davis when he was a government engineer.

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An * denotes the abstract of a paper before the Academy or an affiliated society.

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